TRACKING PROJECTIONS: EXPERIMENTING IN DYNAMIC THEATRICAL DESIGN

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A Project

Presented to the

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In Partial Fulfillment

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Master of Fine Arts in Theatre Arts

with a Concentration in

Design and Technical Theatre

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by

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Spring 2015

SAN DIEGO STATE UNIVERSITY

The Undersigned Faculty Committee Approves the

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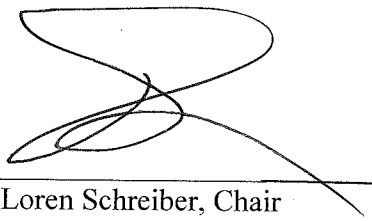
Tracking Projections: Experimenting in Dynamic Theatrical Design



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DEDICATION

6 years ago I walked into a scene shop ready to start a career in theatre, an industry I knew absolutely nothing about. I met a man there who believed in me and my abilities when I had very little to show for myself. He mentored me for several years, helping me to build a strong foundation for my career and instilling in me to always honor the commitments I made. He never told me to go to graduate school and was never the biggest fan of scenery automation, touting that stagehands could do it better. Nevertheless, I would not have made it this far if he had not pushed me early on to work hard and to be better. I still catch myself quoting his mantras.

Even though I know you would not have picked this project for me, this one's for you Todd King.

ABSTRACT OF THE PROJECT

Tracking Projections: Experimenting in Dynamic Theatrical Design
by
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Master of Fine Arts in Theatre Arts with a Concentration in Design and Technical Theatre
San Diego State University, 2015

Advances in stage automation and projection design in recent years have provided new design tools to bridge the visual conversation of contemporary theatre into the technology driven 21st century. A variety of solutions exist to achieve fluid design. This project explored the concept of moving projection images around a stage by using an existing automation and projection software partnership with Creative Conners' Spikemark™ automation software and Dataton's Watchout™ projection software. Using the automation system, I moved a projection screen along a motion path. The automation software sent its position information to the projection software so the projected content followed the moving screen. Proof of this technology's ability to enhance the visual movement of stage design was showcased in the projection design for the SDSU School of Theatre's production of *Alice: Curiouser and Curiouser*, an adaptation of Lewis Carrol's *Alice in Wonderland*. Amidst a multiscreen projection environment, I used tracking projections to further enhance the visual interest created by the overall projection design. The overall goal for this project was to deliver an analysis of my user experience with this software partnership in order to make contributions to the research for improving the system's tuning process that would achieve greater tracking image quality. Separately, these two technology systems are readily available in both regional and university theatre. Thus, improving the process of this system partnership will have a far reaching effect on improving fluid projection design in theatrical environments.

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CHAPTER 1

INTRODUCTION

Before beginning any worthwhile project, it is important to ask the question, where does this all fit? For me, that question begins on a high level. I started the development of this thesis project with asking myself in what artistic conversation am I trying to participate. It then evolved into how does theatre, the industry to which I belong, have this conversation, and then into what practical contribution can I make to this topic. As the culture of virtualization rapidly increases, we must ask ourselves as 21st century artists, how do we bridge the gap between our design and the technological realm? Theatre as an art form has the inherent ability to represent some of the most heightened reflections of life. It is arguably the best medium to comment on technological developments because theatre is a very human way to connect with people.

THE BACKSTORY

The physicality of theatrical performance relies on the fluidity of its movement to contribute to telling a story. The problem that occurs is the juxtaposition of the fluid art of acting with the static art of scenery. For centuries, theatrical designers have reconciled this by creating dynamic sets in which scenic elements move around to change the visual composition of the stage throughout the show, whether it be for a location change or to generate a different audience reaction. Given the current technological culture, the question is how to move the scenery. The development of automation systems for theatre has revolutionized scenery movement, providing the ability to move elements beyond typical utilitarian ways. Stage automation contributes to the idea that man's technological achievements can play an active role in the arts. Though theatre artists tend to hide the mechanisms of movement in order for the scenery transformation to seem magical, an audience is still passively receiving the technological message. The way a group of

stagehands moves an element of scenery is aesthetically different from how a motor moves the same element. Furthermore, automation equipment can hide in places a person cannot, subconsciously communicating to the audience that this piece was not moved by a person. This is key to stage magic which relies on an audience's inability to figure out how an effect is achieved. By decreasing the size of moving mechanisms and developing advanced programming software, the possibilities for automated scenery today are vast. The dynamism and precision with which contemporary technology allows scenery to be controlled truly allows it to participate in the choreography of a performance. These effects enhance the audience's experience and immerse them in the world of the performance.

The developments in scenery automation are not the only important technological advances affecting stage design today. Lighting, sound, and projection design are examples of three disciplines of theatrical design that are pioneering ways to contribute to dynamic stage pictures. These advancements are increasingly used in show control applications. "Show control simply means connecting together more than one entertainment system, and this simple idea can bring amazing sophistication and precision to a wide variety of types of performance" (Huntington 357). Though there are many reasons to link systems together, I find practice of show control is important because of its ability to achieve a level of cue synchronization beyond human capabilities, which has the power to create impressively immersive effects. Furthermore, I believe it encourages deeper collaboration among design and technical disciplines.

THE PROJECT

The above ideas are the foundation of and sentiment behind this thesis project. After seeing the technologically advanced production of *Yoshimi Battles the Pink Robots* at the La Jolla Playhouse in 2012, I was inspired to contribute to the process of fluid design that I found in that show. The seamless coalescence of different technology in that show set a high bar for the future of stage design. Present in *Yoshimi* were the early stages of a partnership between two disciplines: stage automation and projection design. The companies were Creative Conners and Dataton, whose products are used widely by university and regional theatre. By joining their software, Creative Conners's Spikemark™ with Dataton's Watchout™, they enabled an integration that allows a projected image from Watchout™ to

track on a screen that Spikemark™ is moving. Though the capability to achieve automated projections using Spikemark™ and Watchout™ is a few years old, it is still a developing process. When I embarked upon this project, inspired by what I had seen at the La Jolla Playhouse, my goal was to contribute to this integration's development by setting up and testing the two systems together and experimenting with its capabilities. At the start of the project, the instructions in the Spikemark™ 3.2 manual were the only information I could find on how to set this up. Though it was helpful to getting my process started because I did not have to read through several manuals to figure out what boxes needed to be checked in each program, overall the information was very limited. It told me how to open the communication between the two programs, but it did not communicate anything about design considerations or troubleshooting. The last line of the instructions section is, "As you start using this feature in production, let us know how it works for you and send us some video. We love to see this stuff in action" (Creative Conners 209). When I read that I thought this was an excellent opportunity for experimentation and a way to contribute to a developing technology that I believe is an important step towards encouraging the advancement of technology to enhance stage design. With this inspiration, I set the following goals for this thesis project:

1. **To experience the Spikemark™/Watchout™ integration from a user point of view, to analyze the steps needed to deliver the product, and to reflect on ways to maximize the integration's efficiency and quality.**
   Much of the production work done with this integration involved experts in these fields and assistance from the developers. Now that it is a few years old, a bit more refined, and released to the public community of Spikemark™ and Watchout™ users, I took the approach of an end user seeking to use the available information and see if I could actually get it to work. At each part of the process, I would analyze the situation to determine what factors of each system had unique considerations for this integration and then draw conclusions for making choices within the system's design that would produce the best result. Furthermore, considering the theatrical industry is inherently fast paced, if this integration is to be widely used, it needs to be efficient to setup. By analyzing the elements required to operate the integration, I attempted to

gain a better understanding of how they interact in order to make recommendations for a quick installation.

2. **To encourage the development of this integration as another tool for dynamic design given the prevalence of Watchout™ and Spikemark™ in university and regional theatre.**

While the idea of moving digital images around a stage is certainly not a new concept, the tools to do so are frequently cost prohibitive, especially for university and regional theatre. Designers in training at universities are often limited by small budgets and resources. Developing an accessible technology such as this is an excellent way to encourage the consideration of these dynamic design concepts in the next generation of theatrical designers. Part of my approach was to make this integration readily available to future students in the San Diego State Theatre Department. Furthermore, regional theatres are often stops on a production's way to Broadway. This kind of development allows these technological considerations to happen earlier in the design process as opposed to waiting for the bigger Broadway budget.

3. **To explore how an actual implementation of this technology could aid in the storytelling of a production.**

I am a strong believer that the conversation about theatrical technology should not be divorced from the aesthetic conversation. If the goal is to enhance design, then I must consider how this technology could impact a production's story and an audience's experience. To discover how technology can affect a production, I was able to employ the integration of Watchout™ and Spikemark™ for the San Diego State Theatre Department's production of *Alice: Curiouser and Curiouser*. Being on both the design and the technical sides of the project rounded out this experience for me because I could draw from each side to improve the other. In addition, I could go beyond understanding how to setup the integration to discover what it would mean to actually incorporate this into a production. Providing this production example gives me a stronger case to encourage future implementation of the integration.

There are a number of factors to consider when designing projection and automation systems independently of each other. Those factors are still important to this work, however

for the purpose of this thesis they will be discussed only as necessary and not in detail as this in an account of factors specific to the integration of Watchout™ and Spikemark™. The fundamental steps to open the lines of communication between the two systems are the same each time this integration is used. What varies each time are spatial relationships and machinery requirements to achieve an aesthetic goal, which is where I put my focus. In the following sections, I will illustrate the process for employing the Watchout™/Spikemark™ integration by providing an account of my experience testing for and implementing its use in the San Diego State University production of *Alice: Curiouser and Curiouser*. I will first describe its physical implementation and its software integration, and then I will detail a practical application of the technology.

CHAPTER 2

SYSTEM INSTALLATION

Prior to the actual integration of the Watchout™ and Spikemark™ software, it is essential to set up all of the physical components of the system. For this discussion, I will provide an overview of both the Watchout™ projection system and the Spikemark™ automation system to define what elements are required for each, and to describe how I selected the necessary components for my project.

Watchout™ is a multi-display projection playback software. It operates with one main computer known as the production computer and any number of display computers, each connected to a projector as their "display." Each display is associated both with a physical field of projection that will land on a projection surface, and with an IP address to connect it to the Watchout™ Local Area Network. The projection programmer uses the Watchout™ software on the production computer to define each display in the digital world in order to control what content is projected by a given display. In addition, the programmer uses the production computer software to add and manipulate media in a layered Timeline, which, when activated, will output projection content as designed.

Spikemark™ is a multi-axis theatrical motion control software. Similar to Watchout™, Spikemark™ functions with a main control computer that connects via a Local Area Network to any number of units used to motorize scenery in a production. Each motor controls an object with a physically defined axis of movement and is outfitted with a Stagehand motor controller card that is assigned an independent IP address on the network. The automation programmer will then connect the main control computer to each Stagehand card in order to identify what type of motor controls each axis and to set movement and tuning parameters for each motor. From here, the programmer can compose scenery movements and write them into a cue stack for a production.

When I began my project, it was independent of a production, but it was still necessary for me to define what I wanted the end result to be. I knew that I wanted to be able to move a projection screen in a complex motion path capable of moving in the full range of the proscenium opening and to have an image successfully track with the screen during all movement. For the automation side of the project, I needed two motors from the SDSU stock of automation equipment, one to control the X-axis of movement and one to control the Y-axis. Being familiar with the Spikemark™ programming software, I knew that by manipulating these two motors simultaneously I could create complex screen movements. In evaluating the range of movement I was working with, I knew I needed a projector capable of outputting a large display that would cover the screen's full range of motion and powerful enough to produce a high lumen output at the plane of the screen. For this, I turned to the Don Powell Theatre's main projector situated in the control booth.

Though I began with setting up equipment for an independent project, shortly into my testing phase it was decided that I would incorporate this technology into the SDSU production of *Alice: Curiouser and Curiouser*. The tracking projection rig I decided upon remained the same for the production, with the exception of replacing the screen with a show specific projection surface. This rig was situated among a larger set of equipment used for *Alice* that included three projection displays used with five projection surfaces and four axes of automation. In the following sections, I will describe my process for the physical installation of this system and how certain aspects are helpful to consider for future implementations of the Watchout™/Spikemark™ integration.

NETWORK COMMUNICATION

In order to integrate Watchout™ and Spikemark™, an open line of communication must exist between the two systems. The first step of this process is physically connecting each projection and automation component to the same Local Area Network (LAN). Considering each show has different needs, equipment locations are variable. I can predict general locations for the equipment, however I cannot always position equipment in the same spot. This means new cables need to be run each time for power, network, etc. Negotiating these cable runs can be difficult, especially in large scale productions. Given one of the main goals of this project is to encourage continued use of the Watchout™/Spikemark™

integration in the San Diego State Theatre Department, I identified the need for an Ethernet network for the Don Powell Theatre. This would provide network ports at key locations throughout the theatre in order to maximize the efficiency of setting up future automation and projection systems.

Both Watchout™ and Spikemark™ connect via standard TCP/IP compatible Ethernet hardware. The Don Powell network system I created consists of four Ethernet switches Figure 1 is a plan view that illustrates the network switch locations.

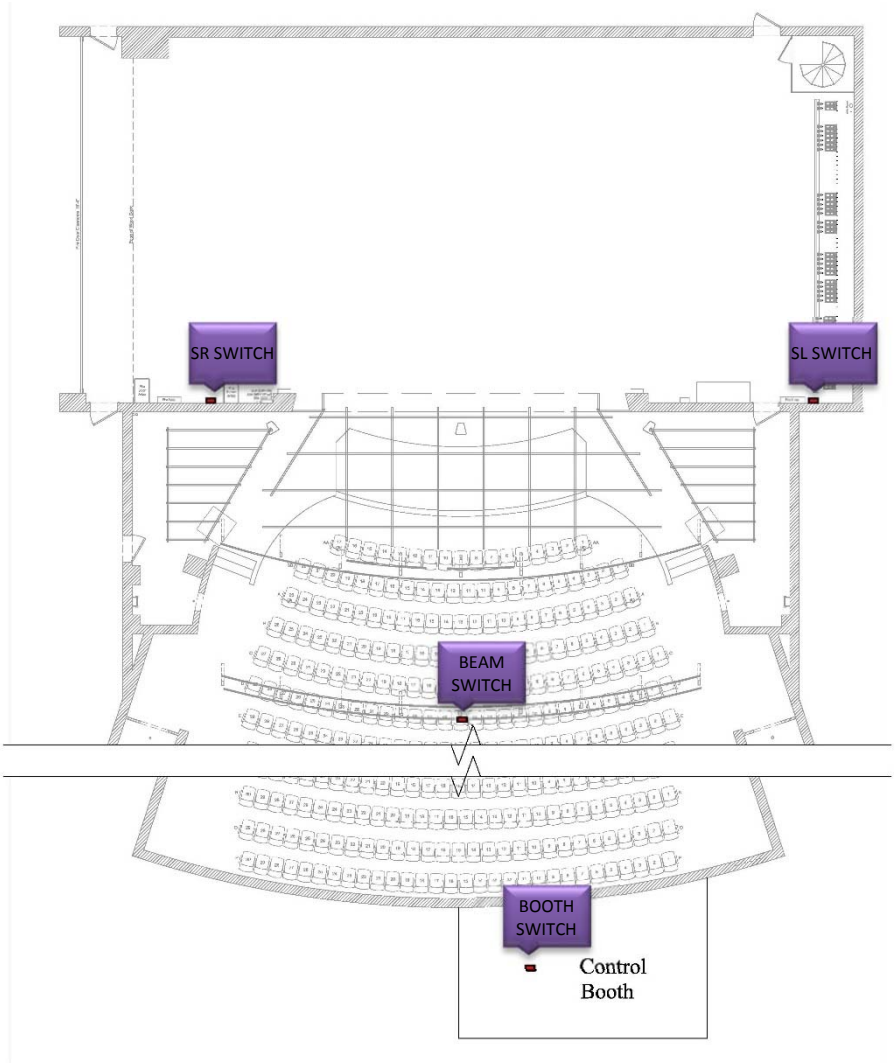

Figure 1. Don Powell Theatre network switch locations.

The Booth Switch was an existing switch placed in the control booth of the theatre for easy access to both the Watchout™ production computer as well as the theatre's main projector and display computer. The Beam Switch was another existing switch that I repositioned to be centralized in the lighting beams above the audience, a frequent position for front projection. The SR and SL switches are new additions to the network system located on the proscenium wall on either side of the stage, ideal locations for connecting stage machinery. In order to increase the robustness of the onstage switches I assembled them into metal enclosures each with 7 Neutrik Ethercon panel connectors. The SR and SL enclosures also act as Emergency Stop hubs for the automation system. Figure 2 shows the inside of one of these enclosures.

Figure 2. Inside of the SL Network Enclosure

Once all of the switches were in place, I ran Ethernet cables from the SR and SL Switches to the Beam Switch and from the Beam Switch to the Booth Switch, thus creating an accessible wired network for connecting all of the projection and automation components. Once all of the components were physically connected to the system, I assigned each piece a compatible IP address. Components will be on the same LAN if the first three numbers of the IP address are the same and the fourth number is unique (Dataton 27). For example, the Watchout™

production computer's IP address was 192.168.10.0 and the Spikemark™ control computer's IP address was 192.168.10.10 and both computers functioned on the same LAN.

AUTOMATION COMPONENT DESIGN

Before I explain the physical design considerations that are unique to the automated projection integration, I will first account in more detail what elements were used in the automation system. The automated object was a Broadway style theatrical flat with a painted muslin projection surface. This screen was capable of moving in two axes. It moved in the X-axis, stage left to stage right, via a custom designed, skate wheel carrier track that is part of the SDSU's equipment stock. The screen hung from two carriers on this track. Driving the left and right movement was a 2HP motorized winch unit capable of pulling a maximum load of 200 lbs at a maximum speed of 4 ft. /sec. In addition, the track and winch hung on a counterweighted batten that moves up and down in the Y-axis controlled by a 5HP winch attached to its arbor. This winch is capable of pulling a maximum load of 900 lbs at a maximum speed of 3 ft. /sec. For *Alice*, I wanted to maximize the plane in which the screen could move to provide the most flexibility in creating motion paths, while at the same time keeping the machinery hidden. Taking into consideration the desired range of motion, the audience sightlines, and the height of the theatre's fly system, I calculated the screen needed to hang 12'-0" below its carriers in order to be most efficient.

Once the physical components were installed and the load, in this case the projection screen, was attached to the system, I was able to tune the motors. The purpose of motor turning is to achieve the smoothest possible motion path given a system's physical and mechanical constraints and imperfections. Tuning is done one axis at a time. To describe the process simply, the motor is written into a cue to bring it to specified location at a given speed. After running the cue, I must evaluate both the quality of its motion as well as the motor's ability to accurately achieve its position. I then need to adjust the tuning parameters for that motor in Spikemark™ and then re-run the cue to evaluate if the changes achieved the desired result. The following excerpt from the Spikemark™ manual provides a simplified explanation for what the tuning parameters are doing:

> The Stagehand is constantly analyzing where the motor is versus where it should be and then adjusting motor power to minimize the difference between where the

> motor should be and where it really is. It does this analysis a few million times per second. When it wants to apply power to correct for error in position, it looks to us for guidance. By entering in some tuning parameters, we are giving the Stagehand that guidance. In a confounding abstract way, we are specifying how much power to give the motor when it needs to make a correction. If the values that we enter give the motor too much power during correction, the motor will be jerky as it over-corrects and then has to pull back (remember, this happens millions of times per second). If the values we enter do not provide enough power to the motor to correct position, it will never reach the cue position since it will run out of power and be unable to muscle the load onto the target. (Creative Conners 83-84)

Understanding Spikemark™'s tuning capabilities is essential to the Watchout™ /Spikemark™ integration. When Watchout™ receives the position information and processes it through the live "tween track" (a Watchout™ specific term that is explained further under Tween Formula, Chapter 3), it simulates a motion path that it is assuming the projection surface is following. There is no sensor or information going in the other direction to assure the image is accurately tracking with the screen. This means that the actual motion path of the projection surface, as dictated by the automation software, must be tuned to the simulated motion path. As I discovered through testing, movement that is not precise to the simulated motion path will result in a noticeable vibration of the image as it tracks with the screen. When using this automation system conventionally, the jitteriness of the screen would be undetectable. However, image tracking highlighted all of the imperfections of the physical motion path. Therefore, it is necessary to this integrative process to spend more time than usual dialing in the tuning parameters.

Being attentive to the mechanical design of a winch unit is a standard concept in automation design but it is beyond the scope of this discussion. Part of physical design that I feel *is* pertinent to discuss is the mechanism from which the screen hangs from its track carriers. During the testing phases of this project, the screen hanger design went through a few iterations. My first attempt was to hang the screen from two 1/8" aircraft cables. I chose a thin cable to minimize the visibility of the hanging points and make the screen look more like it was floating in space. However, I discovered through the motor tuning phase that there was too much lateral movement from the non-rigid cable connection. Spikemark™'s tuning capabilities are not sophisticated enough to smooth the lateral movement out to the level that is necessary for image tracking.

The next attempt I made was to replace the 1/8” cable lines with 1” square steel tubing to make the connection rigid. While this eliminated the lateral sway the screen had with the cable, it created a rigid jerkiness to the movement, which could be minimized with proper tuning, but not eliminated. Under these conditions, the screen’s movement would be considered good for normal scenery automation applications. Furthermore, for simple movements, this setup allowed for image tracking that was relatively smooth with vibration that was not detectable from the audience. However, when more complex movements were introduced, the tracking quality diminished enough for the vibration to be noticeable.

The final touch that yielded a suitable result was to make the hanging frame more rigid by adding diagonal bracing between the two hanging tubes using 1/16” aircraft cable. This added enough rigidity for the screen to make a smooth complex movement. The downside of this hanger design is that it is significantly bulkier than the first iteration and required negotiation with the lighting designer to minimize its visibility. Achieving the aesthetic effect of a floating screen under the conditions of the integration is inherently problematic because reducing the structure stresses the automation system’s tuning capabilities. Designs in which the structural necessities of the hangar could be incorporated into the screen’s design would create a stronger path to the success of the tracking projection.

The test-and-adjust phase of the automation installation proved it was necessary to consider how the structural design of an automated piece of scenery will affect the ability of Spikemark™’s to generate a smooth motion path. Knowing the capabilities for each component of the system and being careful during the machinery installation is valuable during the programming phase because it will reduce the time needed for troubleshooting and fine tuning. Matching an automated motion path to a computer generated idealized path is nearly impossible. However, with the above methods of hanger design and with careful cue programming, which will be discussed under Cueing, Chapter 3, I was able to generate a path smooth enough that the imperfections of the image tracking were minimal from the audience’s point of view.

CHAPTER 3

PROGRAMMING

Once the components were in place and the physical parameters were set, it was time to actually make the software integration happen. With Internet Protocol as the underlying protocol, Spikemark™ uses User Datagram Protocol (UDP) to transmit packets of position information to Watchout™. In this instance, UDP is the preferred method of message delivery because of its simplicity and speed ("User Datagram Protocol (UDP)"). I consulted the Spikemark™ manual for instructions on how to configure the software so that Spikemark™ would send its position information via UDP to the correct server port on the Watchout™ production computer. On the other side, I needed to tell Watchout™ to listen to the UDP information. The instructions can be found in Appendix A (Creative Conners 196-209). In the following sections, I will analyze the different aspects of configuring and programming the software to make this integration successful as I experienced it through testing the system and using it in San Diego State's production of *Alice: Curiouser and Curiouser*.

SPATIAL RELATIONSHIP

Syncing Watchout™'s outputted image position with the automated screen's position relies on both Spikemark™ and Watchout™ recognizing the same physical parameters of the stage. In order to understand how the two systems spatially sync with each other, I will describe how each program recognizes the physical space.

In Watchout™, there is a Stage window in which display fields are placed virtually. Each display is delineated as a box, the dimensions of which are given in pixels and correspond, in most cases, to the native resolution of the projector with which the display is linked. The origin of the stage, according to Watchout™, is the top, left corner of the Stage window. The placement of the display box within the Stage window theoretically is arbitrary.

Typically, the displays are placed in a logical location, relative to where the corresponding projected surfaces are to aid in the visualization of cue building. Each display when added is assigned the IP address of the display computer that is controlling it. Watchout™ will not output any projected images without an added, linked display window. Consequently, only images placed within the field of display will be output from the projector. The placement of the display within the Stage window is inconsequential to the projector because the projector is manually focused at the unit. Once the physical space is set in terms of screen placement and its surroundings, the projector can be shuttered and focused to the given location. Though displays in Watchout™ can be nonspecifically placed, they do contain coordinates for their location relative to the Stage window's origin. This information becomes very important when preparing to connect with Spikemark™.

Spikemark™ necessarily ties itself closer to the physical world given the safety requirements of stage machinery. The Spikemark™ system receives its position information from encoders attached to the motor units. There is no global origin for all machinery being controlled, but rather each axis can have a Home position set and the software will retain its position from Home along its full axis of movement. The limits of the axis are defined by the physical space in which the axis exists. Therefore it is a necessary part of the automation setup process to know and understand the physical limits and to set the position information in the software according to those limits. There are several options for position units in the software: counts, inches, feet, millimeters, and degrees. In my setup, I used inches. Spikemark™ also will allow the encoder information to be either positive or negative. Therefore, if the 0” position of the automated unit is somewhere in the middle of the axis, the position information will be positive going one direction from 0” and negative in the other direction.

With this understanding, I will describe the spatial considerations for the integration as it relates to the production of *Alice*. Since Spikemark™ allows user definition of an axis origin, whereas Watchout™ has a fixed origin and fixed positive quadrant, my overall approach was to first place the display window in Watchout™ and then manipulate the position numbers in Spikemark™ to recognize where the display field was in real space. I found it helpful to think of Watchout™’s origin as the upper, left corner of the theatre space, beyond what the

proscenium or portal opening was. I wanted to relate the Watchout™ Stage window to the actual plane of the moving screen which would not only move within the display field, but it would also move up and out of sightlines. I also wanted to see the image tracking in the Stage window with the moving screen both while it is outside of the display and as it crosses into view. This meant I needed to be precise about where in the Stage window I placed the display associated with the integrated projector. I created a display in Watchout™ that was 1920x1080, which is the native resolution of the projector I was using. I then placed it at the pixel coordinates 1517, 1500 from the Watchout™ origin and associated it with the display computer of the projector with its IP address of 192.168.10.11. In this instance, the display field was representative of the stage opening as determined by the scenic design and masking portals. This was sized to allow for a projected image within the full field of travel of the automated projection screen. The display's distance from the Stage window origin corresponded to the physical space around the screen's visible field of movement.

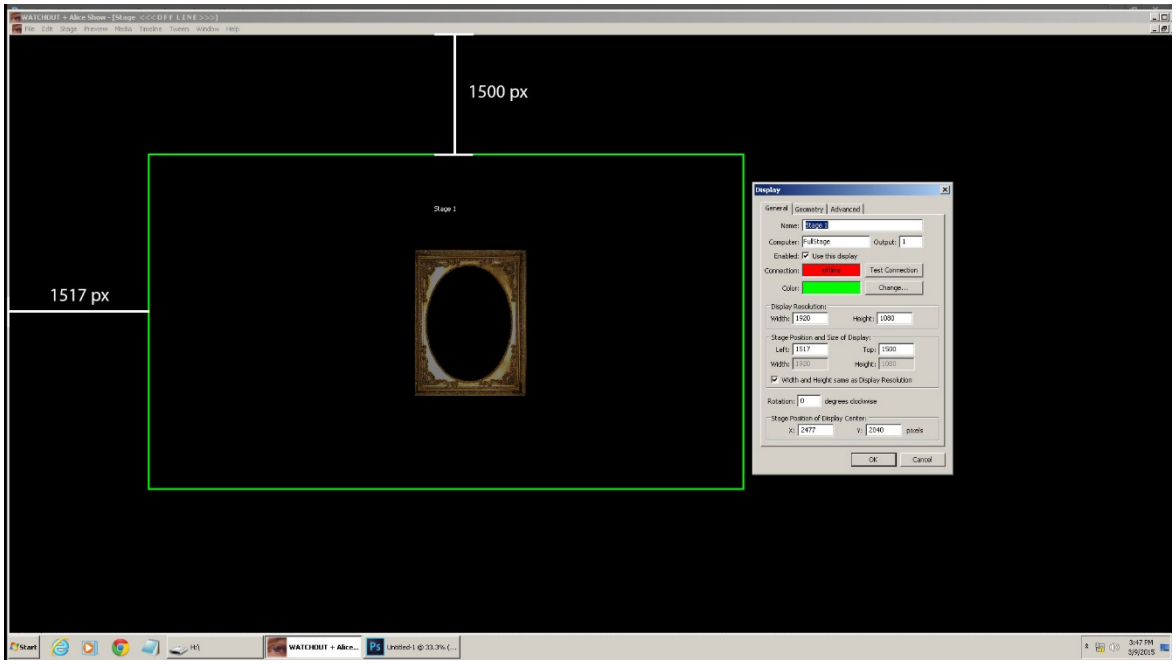

Figure 3. Watchout™ screen shot showing the projector's display box within the Stage window.

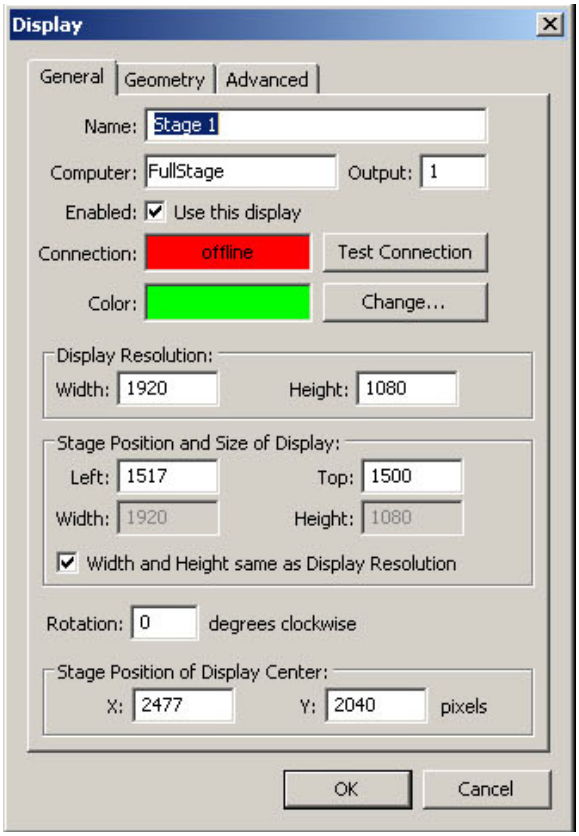

Figure 4. Detail of Watchout™ Display information.

Once the display was placed in Watchout™, I could set the position parameters for each axis of the screen's movement in Spikemark™. Standard practice for axes of motorized scenery dictates the use of limit switches at the extremes of an axis to prevent the moving scenic element from traveling farther than it physically can regardless of what the control computer is telling it to do. In Spikemark™, I needed to figure out the "soft limits" of each axis of the screen, which correspond to the screen's position before it would hit its hard limits. In this setup, the screen could safely move 320" in the X-axis and 237" in the Y-Axis. Normally, I would pick a logical Home position for the screen, and at that spot set the position for each axis to 0". I then would set each motor's maximum position as the furthest amount it could safely travel in that direction (this number could be negative or positive depending on the encoder direction). However, given the need for Watchout™ to receive and correctly interpret the position numbers, the process for setting position programming parameters was tricky.

Ideally, Watchout™ and Spikemark™ would recognize the same origin and positive quadrant, however this was not the case for the *Alice* rig. If the origin for the Spikemark™ setup was, when facing the stage, in the upper left corner and the screen traveled on stage and downward, both motors would be generating negative position numbers. Watchout™ reads negative input information as 0. So, if a Spikemark™ cue were to run in a direction in which the position numbers were negative, despite the fact that is it sending out its position messages, the image would not move in Watchout™ because it would think it was at 0 the whole time. To remedy this requires negotiation of position numbers in both Watchout™ and Spikemark™, a topic that will be further discussed under the subheading Offset under the heading Tween Formula. Figure 5 depicts the final position programming parameters for the *Alice* configuration.

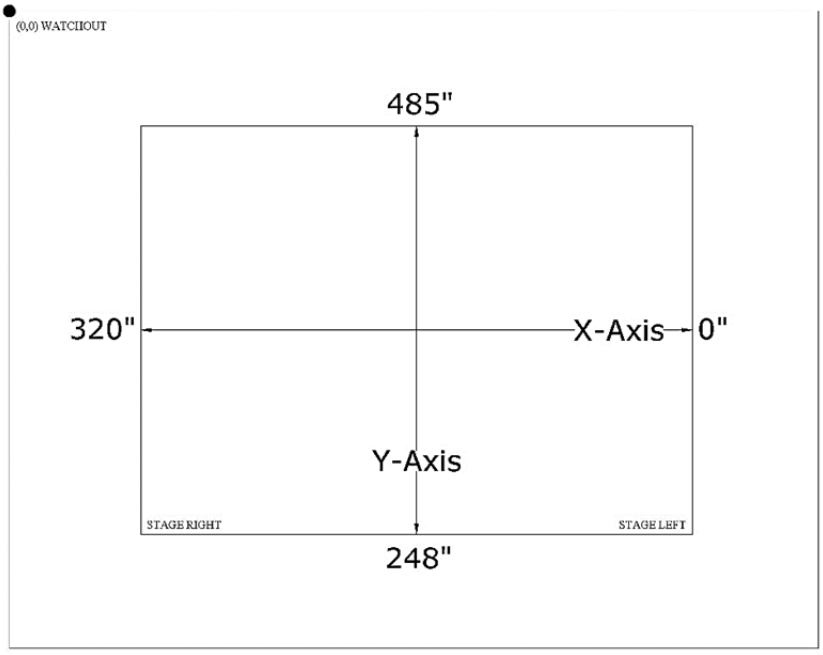

Figure 5. Spikemark™ position programming parameters for *Alice*.

TWEEN FORMULA

In Watchout™, a tween track is a specification placed on a piece of media that is designed to dynamically manipulate the media it is applied to during a cue. Many tween tracks can be externally controlled by a variety of inputs (Dataton 69). For the production of

Alice, I used motor input values from the automation system to control position tween tracks. One of the trickier and more complex parts of working with this integration is developing an accurate tween formula to associate with a given position track. This formula is unique to every instance of this integration. In this application, each motor, filtered through Spikemark™, functions as a generic input in Watchout™. A live tween situation occurs when the stream of incoming Spikemark™ information is associated with a position track. The tween formula in this case functioned both to associate the motor information for the X and Y axes with the tween values for the X and Y axes of an image's position and to translate the incoming data for Watchout™ so it knows in its system where the image should be. Writing the formula involves knowing the name of the motor input as defined by Spikemark™ and two numbers: Pixel Scale Factor and Offset.

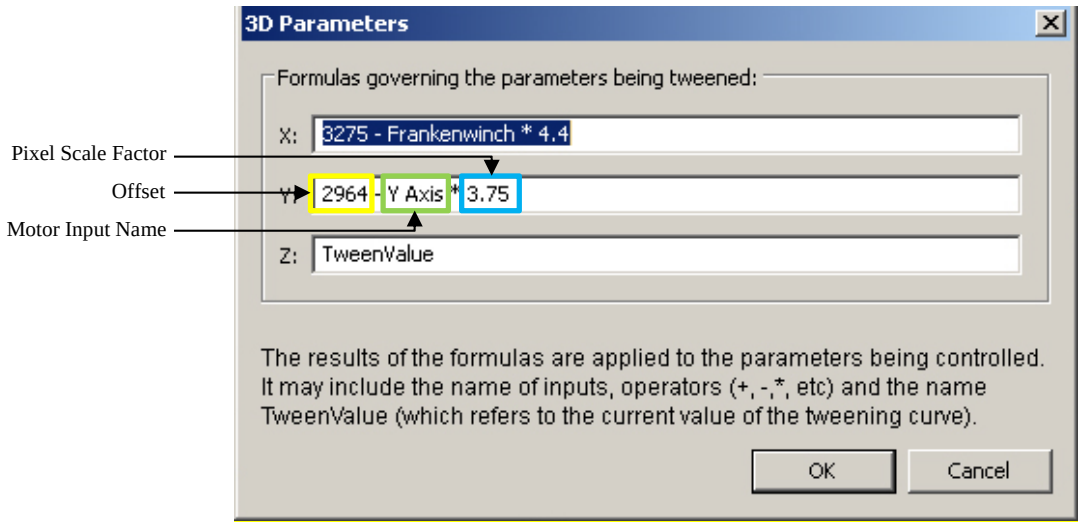
Pixel Scale Factor
Offset
Motor Input Name
3D Parameters
Formulas governing the parameters being tweened:
X:
3275 - Frankenwinch * 4.4
Y:
2964 - Y Axis * 3.75
Z:
TweenValue
The results of the formulas are applied to the parameters being controlled. It may include the name of inputs, operators (+, -,*, etc) and the name TweenValue (which refers to the current value of the tweening curve).
OK
Cancel

Figure 6. Tween Formula dialogue box

Pixel Scale Factor

A pixel to inch ratio refers to the actual dimension of a single pixel when it comes into contact with a projection surface. It is determined by the native resolution of the projector and the projector's proximity to the projection surface. This is a natural consideration for projection design to ensure the proper resolution of media is used for a given application. With the Watchout™/Spikemark™ integration, the pixel ratio plays a large role in determining the accuracy of the image tracking because it is the scale factor

Watchout™ uses in its tween formula to translate the incoming unit inches from Spikemark™ to Watchout™'s unit pixels. When I began the testing phase of this project, I used a projector calculator to determine what the pixel ratio would be for my setup. The projector employed for the tracking is a Panasonic DLP Projector with a native resolution of 1920 x 1080. The projector is located in the control booth at the back of the theatre with its lens positioned at the center of the stage opening. The distance between the projector and the plane of the tracking screen for *Alice* is approximately 100'-0". When I initially projected an image onto the screen, I determined the pixel ratio for this relationship to be 4.48:1. This is the scale factor that I began with when I wrote my initial position tween formula for the tracking image, testing in the Y-Axis.

I ran the projection screen up and down with a static image tracking with it. What I discovered using 4.48 as the scale factor was that the image tracked ahead of the screen. I concluded I was telling the image to travel too many pixels per inch of screen travel, so I gradually reduced the scale factor and continued to run the screen up and down until I reached the correct factor of 3.75, which had the image and screen synced in motion. At this point, it seemed that this setup required a static pixel ratio that was different than the kinetic pixel ratio. I then ran tests in the X-Axis. I began with a tween formula that also used 3.75 as the scale factor, assuming this factor was purely related to the projector's distance to the screen. My first test revealed that the image was lagging behind the screen. Similarly to my Y-axis tests, I gradually increased the pixel scale factor in the tween formula until the image and screen were synced in the X-Axis. The resulting number was 4.4, nearly the same as the static pixel ratio I had calculated. I then concluded there were several factors contributing to the scale factor including but not limited to the type and resolution of the encoder attached to the motor and the image size varying as it moves through the field of projection. Further experimentation to understand the pixel scale factor is underway, however I have not yet drawn a conclusion on how to predict the number more accurately.

Offset

Once the pixel scale is determined and the base formula is written, it is time to analyze the numbers Spikemark™ is sending to Watchout™ to determine if an offset is needed in the Watchout™ tween formula. Under the heading Spatial Relationship, I began

the explanation of how the two systems determine location in the physical space. An offset is introduced into the equation when the direction of positive position information from Spikemark™ is opposite from the direction that Watchout™ deems positive. Since both of the winches used in the *Alice* setup had positive encoder direction that was opposite of the positive Watchout™ direction, both of the position tween formulas required offset values. The offset value is a distance, in pixels, relating Watchout™'s origin to an image's anchor point that equals the full length of screen travel in a particular axis, plus the distance the display window is set from the Watchout™ origin, and plus the distance to the image's anchor point. That value then has the rest of the formula subtracted from it. What this does is mathematically switch the direction the image will travel in Watchout™ so that it matches the Spikemark™ direction, provided that all incoming numbers from Spikemark™ are positive. For the X-axis motor, this was straightforward because the full distance the screen can travel horizontally in view is almost equal to the width of the projection display. Given the sightlines for the screen, it never traveled out of sight in the horizontal direction, so I did not need to account for that distance in the offset. Therefore, it was possible to use the offset to move the Watchout™ 0 to the Spikemark™ 0" in the X-Axis.

The Y-axis was more complicated because it required manipulation on the Watchout™ side as well as the Spikemark™ side. The reason for this is that the screen's full travel height is the height of the display screen plus the distance it needed to travel out of sightlines. What I discovered while testing the screen is that if I set the screen's lowest position number in Spikemark™ to 0", and then used the offset to change Watchout™ to recognize this as its 0, the position was off. This proved to me that if Watchout™ was going to subtract the distance from the top of the projection field to the top of the screen's travel, Spikemark™ needed to account for that distance in its position numbers. The easiest way for me to do that was to set the low position number in Spikemark™ to 248", which is equal to the distance the screen moves up beyond visible stage window. This range of numbers (248"-485") processed into the Watchout™ tween formula so that Watchout™'s projected motion path matched the actual location of the screen.

CUEING

Once the two programs had the same spatial understanding for the needs of the production, and I had accomplished successful accuracy tests, I composed tracking sequences. A sequence requires programming in both Watchout™ and Spikemark™. These programs have fundamentally different styles of creating cues. In Spikemark™, cues are written in a stacking order. Each targeted movement is written as an independent cue with the option of being linked to another cue. An operator presses a go button to trigger the cue, the cue will run to completion, and the operator can load the next cue in the stack. Watchout™, on the other hand functions in a Timeline. Cues are written by adding layers of media to the Timeline, composing their placement in the Stage window, and adding tween tracks for a desired effect. Playing the Timeline will run through any media sequences present at that time in the show. A simple use of the Timeline, and the one used for *Alice*, is to add a pause button after each desired cue. Therefore the operator plays the Timeline and a sequence plays until the pause button, which pauses the Timeline until the operator hits play again.

Though it may appear that Spikemark™ is controlling Watchout™ when a cue runs, this is actually not the case. Running a Spikemark™ cue will not trigger the Watchout™ Timeline to play a cue. Spikemark™'s running cue simply sends the information out as it is running to the media that is linked to the information. All that is required in Watchout™ for a static image to track with the screen is for a synced item of media to be active in Watchout™'s Timeline. If the Watchout™ cue requires the Timeline to play, such as in the case of a video, a separate projection operator is required to play the Timeline at the same time the automation operator runs the Spikemark™ cue. Because Watchout™ is constantly receiving position data from Spikemark™, there is a good amount of room for operator error. If both the Spikemark™ and Watchout™ operators do not hit the go button at precisely the same time the Watchout™ image will automatically jump to the screen's position. For obvious reasons, with the screen starting out of sightlines, there is more room for this error than if the screen moves in view the whole time. During *Alice*, I employed a few different cueing styles for this integration, which were all successful. In Chapter 4, I describe in detail how I generated each tracking projection sequence.

When writing a cue in Watchout™ for this integration, after the necessary steps are taken as detailed in the Spikemark™ manual to allow external control of the media, much of the methods are the same as without having it linked to Spikemark™. The exception is that the linked media cannot freely move around the Stage window. Therefore, this created a tedious situation when I needed to adjust the media's placement on the projection screen because I could not just drag it into place. My first method of adjustment was to keep all of the offset values the same for each image's tween formula and then adjust the anchor point of an image to place it where I wanted it to be on the screen because this was faster than modifying the tween formula each time. However, when I wanted to add rotational tween tracks to some of the media, I found I needed the anchor points to be at the center of the image. At this point, I reset all of the images' anchor points to the center of each image and made adjustments to image position via the offset in the tween formula.

While writing cues for the integration in Watchout™ is more tedious and repetitive than it is complex, developing the screen motion paths in Spikemark™ requires significantly more attention. Beyond motor tuning discussed in Chapter 2, another factor in delivering a smooth motion path is in the actual writing of a cue. In general, when writing a cue in the Spikemark™ program, I first determine each axis that needs to move in the cue and then I individually add those motors to the cue. I then specify the position each motor will move to, the speed at which it will move, and the rate at which it will accelerate. Understanding each motor's overall capabilities and nuances of movement is important, especially when I want the screen to move in two axes at once in a complex cue. Considering the differences in mechanical design between the two winches that controlled the screen's movement, I needed to be attentive when setting each motor's speed and acceleration rates. It was important that I pay attention to the needs of each motor so I would not write cues that would jerk the motor into movement or stop it too quickly. Doing that would add more inertial movement to the screen which would cause the motor's tuning parameters to react in a way that would lead to uneven movement.

For *Alice*, I had two complicated motion sequences to write, which are illustrated in Figures 7 and 8. Both required movement simultaneously in the X and Y directions in an undulating pattern. I first began by writing a series of cues with both axes that would bring

each motor to a given position, with each motor taking about the same amount of time. One cue would follow the other using a completion link which began the next cue when the parent cue completed. What I noticed right away about this movement is that it was choppy and caused the tracking image to appear to jump abruptly when one cue would end and the next would begin. The action of both motors ramping down completely and then ramping up immediately after was causing pauses in the motion path that added jerkiness to the screen. I then adjusted the sequence so that cues would trigger with position links instead of completion links. My thought was that not waiting until the cue completed would limit pauses at direction changes. This improved the movement significantly. I was able to dial in speed and acceleration to make a relatively smooth path. However, once I tested the image tracking under this condition, it accentuated the bit of pause that remained at a direction change.

My final revision of cue sequence writing provided excellent results. To begin the sequence, a cue started the screen moving in the X direction for the full amount of its travel for that cue. The start of this cue triggered a series of cues for the Y axis motor that would move it up and down while the initial cue continued to move the screen laterally. I wanted to eliminate one of the motors ramping, which I could do with the X axis motor because its direction was consistent during the move. The Y axis motor required multiple cues because it needed to change direction. I incorporated position link triggers for the sequence of up and down cues and refined all of the settings until I had two paths of movement that allowed for smooth image tracking.

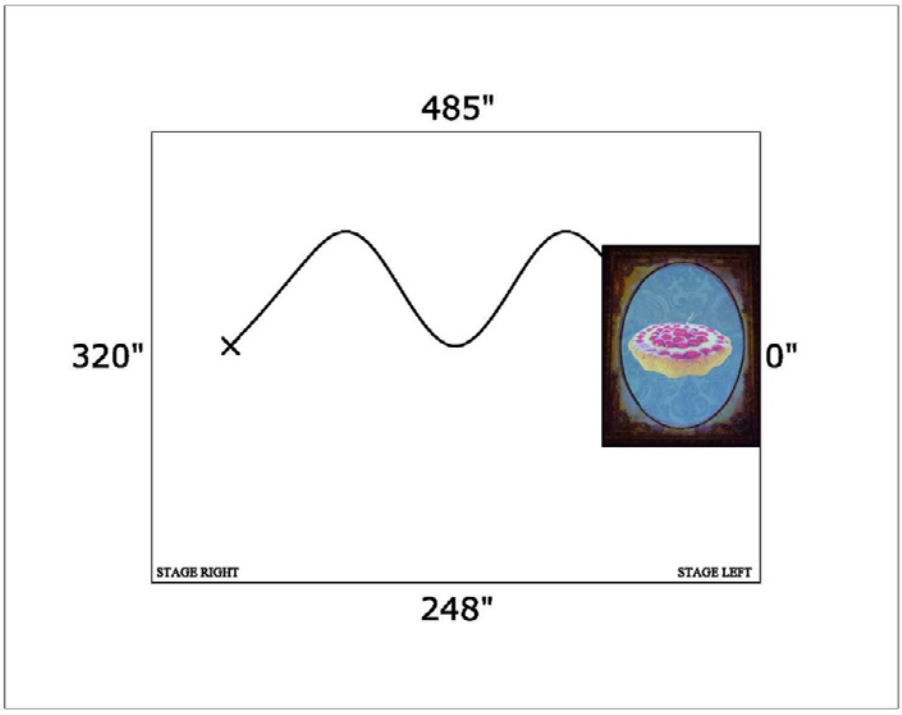

Figure 7. Motion path representation for the Tart Dance Scene in *Alice: Curiouser and Curiouser.*

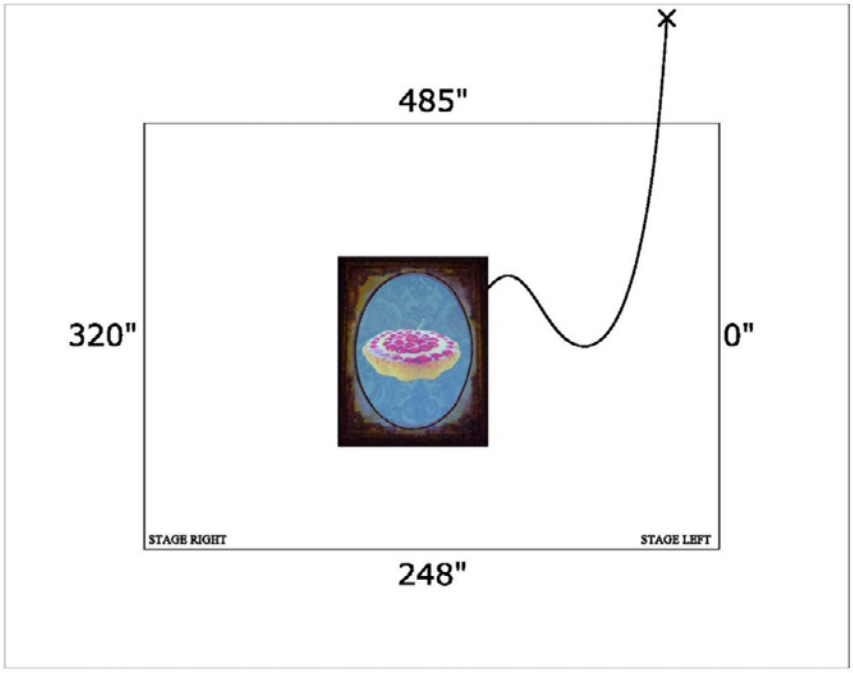

Figure 8. Motion path representation for the "Drink Me" Potion Scene in *Alice: Curiouser and Curiouser*.

MEDIA DESIGN

Being aware of the functional imperfections between the actual motion path of the projection surface and the idealized Watchout™ motion path, it is worth considering ways to design the media content to reduce the audience's perception of a difference between the paths. This was a main lesson I learned during the creation of the *Alice* tracking projection design. Figure 9 shows a side by side comparison of the projection screen designed for this effect by the scenic designer and a static image of one of the moments this effect was employed. What I designed for the tracking projections for *Alice* was perhaps the most difficult application for the integration of these systems. As shown, the projected content of the screen matches the exact size of the screen. This is the root of the difficulty. Projecting to the exact size of the screen as well as using the painted oval geometry on the screen allows for no error between the actual and idealized motion paths. Any deviation in the projected picture frame and the actual picture frame would be noticeable. This is an example of trying to use an imperfect system perfectly.

Figure 9. Photographs of the *Alice* tracking screen with projected show content and without projected content.

There were a few reasons I designed the media in this way despite its difficulty. First, the screen was designed to be an oval shaped portrait frame with a tromp l'oeil frame and a white oval in the center to be the projection surface. Therefore, I was immediately restricted to using the oval line. This required me to create an oval shape in Photoshop that proportionally matched the oval of the screen. I did that by importing the scenic designer's paint elevation of the screen into Photoshop and drawing an oval that matched the shape of the picture frame's oval. I then brought the oval into Watchout™ to employ as a mask for the content that would go inside the oval. This means that Watchout™ would use the oval mask to "crop" the image to that shape, thus creating a hard projected line that needed to follow a hard painted line on the screen. Had this been the only restriction for the media content, I could have feathered the oval mask to reduce the hard line of the projected content to make it less noticeable if it was not perfectly following the painted line of the screen as it traveled on its motion path. However, once I began to look at the screen under show lighting conditions, I realized the painted frame detail was falling really flat next to the bright projected content of the oval. The lighting designer was not able to assist in brightening the frame as he would not be able to isolate the frame across its path of movement without washing out part of the projection. I then went back to the paint elevation of the screen's picture frame and added that as another layer in Watchout™ to project the image of the paint elevation onto the actual painted treatment. This was incredibly successful visually. It gave the painted frame a lot of depth. Though, it required the projection of the frame to follow the hard lines of the screen. The deviation of the projected frame and the painted frame when the screen was in motion was, understandably, the most noticeable discrepancy of the motion paths because it is a level of precision that the system is not currently designed to handle. Any images projected in the middle of the oval, such as the cherry tart shown in Figure 9, appeared smooth from the audience's perspective because there was nothing to reference it as being slightly out of sync. I found a way to reconcile the problem that I believe generated the best success for the design. I first reduced the opacity of the projected picture frame. This reduction of light made the deviation between the two paths not as harsh. I also oversized the oval mask so that it was large enough to accommodate the range of deviation and not show its line next to the painted oval line. In this application, the aesthetic need to have a lit picture frame outweighed the

imperfection of its path relative to the screen's path. However, for future applications, I would recommend avoiding tight tolerances for a tracking projection. Truly revealed through this process is that the design of the media can play a crucial role in compensating for the discrepancies of the motion paths.

CHAPTER 4

SHOW IMPLEMENATION

Advancements in theatrical technology continue to increase the repertoire of stage effects with which one can design. Scenic technology, in particular, can significantly aid in the ease and precision of complex scenery transitions. Though it is important to note that incorporating scenic technology into a production is more than simply a functional consideration. Employing this technology has the power to create dynamic visual compositions that contribute to the choreography and storytelling of a piece. The tracking projection system is an example of employing technology in this way. This makes it an excellent tool for experimenting with how to design aesthetically with scenic automation. Using this setup for the San Diego State University production of *Alice: Curiouser and Curiouser* was an exciting way for me to begin this exploration.

Typically, the decision to use certain technology in a show is made alongside the rest of the scenic design. However, I was in the process of discovering how to setup and operate the tracking projection rig independently of the *Alice* design process. So, the decision to include it was well after the scenery was designed. This had both benefits and drawbacks. First, it allowed me, the director, and the scenic designer to understand the other side of the art and technology relationship. While most of the time in theatre the artistic decisions necessitate the design of new technology, in this instance the technology drove the creation of new artistic ideas. Furthermore, we were able to find parts of the show that were challenging to stage and use the tracking projections to enhance the moment. The difficult side to incorporating this setup after the scenery was designed is that decisions for the location of the rig and for the size and shape of the screen were restricted to fitting into the existing physical and aesthetic world of the design. While overall it was a good compromise that allowed the tracking projections to be successful, it presented design limitations for me that could have been resolved had we been able to collaborate earlier in the design process.

For example, my field of movement was limited by the placement of other scenic elements and by the audience sightlines created with the masking curtains. I could not move the screen horizontally out of sight. It always had to exit upward. This both added an element of predictability to its movement and also made programming complex motion paths more complicated because I had less space in which to make dramatic movements. In addition, perhaps the biggest challenge that faced my design process is the one discussed under the Media Design heading of Chapter 3. Now that I have a better understanding of the design of this technology, when I next employ it I would negotiate for a screen design and paint treatment that would mask the imperfections of the technology.

INITIAL CONCEPTION

The first time I met with the director for *Alice*, we discussed what the full technological capabilities of the tracking projection screen could be. She was drawn to its lateral movement and its ability to break up the existing patterns of scenery and movement present within the set. She wondered how its movement could accentuate the idea of floating thoughts and how it could enhance the unexpected feelings of Wonderland. From this discussion, we thought through the show and identified moments where the tracking screen's inclusion would be appropriate. As she visualized ideas during her rehearsal process, I read through the script to get a feel for when the tracking projections could amplify the storytelling. The projection list went through an iterative process as we approached the time for technical rehearsals. New ideas were added and old ideas were cut. For example, upon reading the script, it seemed natural to want to include the screen's ability to be in multiple locations for the scene when Alice meets the Cheshire Cat. During the scene, the Cheshire Cat disappears and reappears at random. I felt that projections could be a good way to move the character around the stage and have his image appear and disappear in addition to the actor's movements in order to accentuate the magic of his character's elusive nature. However, once I saw the scene performed in rehearsal, it became clear that trying to use the projections in this way would be cumbersome for a quick paced scene. The staging of the actor in this scene was the stronger choice.

Ultimately, as we worked through the design and rehearsal process, we settled on four cues for the tracking projection screen where its use would be helpful and appropriate. Two

of the cues were in Act 1, first helping us transition Alice into the garden of Wonderland and then as an illustration of imagination for how the "Drink Me" potion tastes. In Act 2, the screen is used first in the Croquet scene when Alice sees a large, looming image of the Cheshire Cat's face. It then supports the whimsy of the Stolen Tarts Dance as it carries an image of a tray of cherry tarts across the stage. Each cue of the tracking projection screen illustrates different capabilities of the system. The cues include static images, animated images, and video, as well as follow varying motion paths around the stage. The following sections provide detailed descriptions for how this system was applied in each instance.

ALICE SEES INTO THE GARDEN

Arguably the strongest use of the tracking projection screen is this movement that occurs early in Act 1 of the show. After falling down the rabbit hole, Alice has found herself among many doors. She finds one small door especially curious, though it is locked. With the help of the Enchanted Table character, she finds the door's key. The door is positioned, from the audience's point of view, in the lower left corner of the stage. At the point where Alice kneels down to open the little door, the tracking projection screen flies in center stage playing a video of a close up of Alice's eyes catching the first glimpse of the Wonderland garden. When the screen reaches its downward position, the video of Alice's eyes freezes with her looking directly towards the audience. On her line, "It's the loveliest garden I ever saw," a spinning flower appears in each of her eyes and lasts through the moment of her peering into the garden.

The idea grew out of the director's desire to have the moment of Alice looking through the door be prominent and understandable that she was looking into the physical Wonderland garden onstage. I began creating this sequence with a video clip of Alice's face close up in front of a green screen, looking around as if she were peering for the first time into Wonderland. Considering the quick timing of the scene, I knew I needed less than 10 seconds of video from when we first see the screen to its final lowered position. I selected an 8 second clip from the video that ended in a moment of Alice looking out to the audience, wide-eyed. The challenge with this media and the screen shape was that we wanted to see just her eyes close up, a landscape oriented view, but the screen had a portrait orientation. This showed her entire face in the portrait and restricted how far I could zoom in on her eyes.

I put a feathered border around the video so it looked like Alice's eyes were lit up in a dark cave-like setting, mimicking where they were. In Watchout™, I blended the end of the video into a still of her eyes. To get the spinning flower effect, I manipulated a flower shape image in Photoshop and gave it a glossy sheen. This coupled with an opacity tween in Watchout™ allowed me to slowly ghost in the flowers to her eyes. I initially just had the flower fading up, however when I heard the scene's twinkling magical sound effect playing as I watched the projection, I felt this moment needed a matching animation, which is when I added a rotation tween to the flowers.

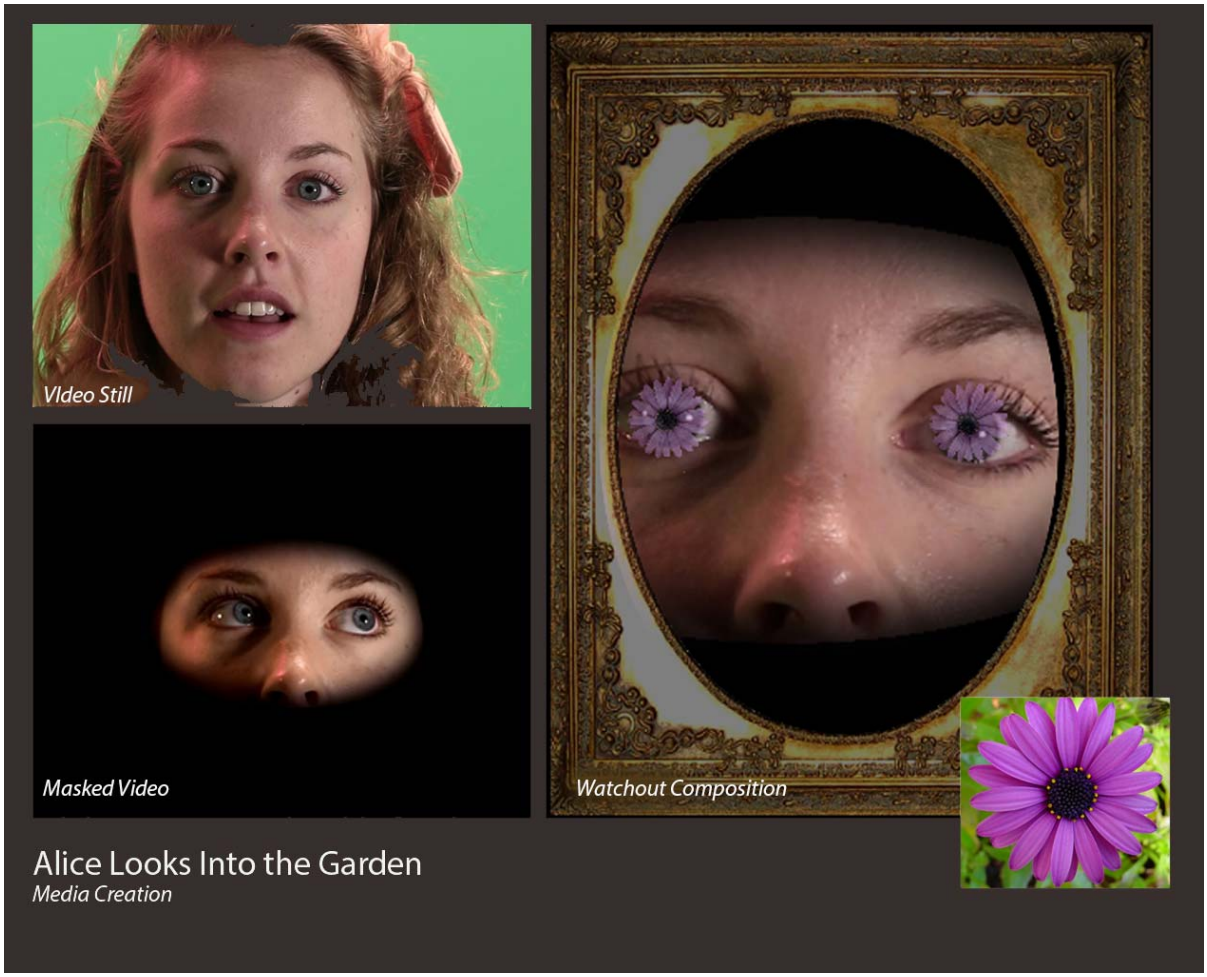

Figure 10. Alice Sees into the Garden media storyboard.

The motion path for this scene was a simple down movement in the Y-axis. I felt center stage was the appropriate choice for this path because it balanced the action happening

in the downstage right part of the stage. Triggering this sequence required two operators, projection and automation, to press go at the same time. The timing of this cue was tricky. Since the screen was at its maximum out position, I needed to allow the Y-axis motor time to ramp up to speed and bring the screen in view, however I only had 8 seconds of video to use. Selecting the right moment for the "Go" took several iterations. The most helpful thing I did was take a video of the scene in performance and watch it while I ran the cues, in order to figure out when the stage manager should call this cue. Ultimately I knew the automation cue needed to run before the projection cue so that the screen could get into position at the time the video started playing. In order to aid in the stage manager's calling of the cue, I delayed the start of the Watchout™ sequence so both cues could be called at the same time and the video would be timed correctly to the movement.

The movement of the screen enhanced this moment more than a static projection screen could have. A curious feeling was added to the scene when we watched Alice's eyes darting around as they descended into the stage window. It looked as if Alice was seeing different aspects of Wonderland as the screen traveled through it. Her awe of Wonderland was amplified when the video paused as the screen stopped moving, showing a stylized image of her eyes with animated flowers until they slowly fade out at the end of the dialogue.

"Drink Me" Potion

This sequence showcases the full capabilities of the tracking projection system. It includes both a complex motion path and changing projection images. This cue happens right after the "Alice Sees into the Garden" sequence fades away. After Alice sees into the garden, she longs to be small enough to fit through the tiny door and experience that world. At this point, the Enchanted Table lures her to drink a potion to change her size. He addresses the audience asking the question, "What does she taste?" Then, to the beat of the scene's music, he lists the potion's tastes as "Cherry Tart, Custard, Pineapple, Roast Turkey." Alice joins in for a second round of this list agreeing to what she tasted. The projection screen begins in the same position in which it ended during the "Alice Sees into the Garden" scene, at center stage. As the Enchanted Table begins his list of tastes, images of the items flash on the screen behind him. When Alice joins in, the screen begins an undulating diagonal movement going stage left and up out of sight while the taste images continue to flash on the screen. At the

same time the screen begins moving stage left, a nearly 12’-0 tall Giant Alice character enters from stage right balancing the screen’s movement visually and also conceptually. It seems the potion Alice drank in this scene made her grow instead of shrink.

This moment was conceived of by the director as a way to create an interesting illustration of thoughts floating through the air. I began by collecting different images of the food items listed and tested what they looked like projected on the screen. I paid attention to how the image was framed by the oval as well as the quality of lighting in the image. I wanted bright images of the food items that would stand out in a fantastical way. I included a background for the images so they looked like portraits in the oval frame. Considering the design of the frame itself and the world Alice came from, I chose a Victorian wallpaper pattern, which I manipulated in Photoshop for a fitting color for the scene. Figure 8, p. 24 shows a photograph of part of the media for this sequence with an illustration of its motion path.

The motion path for this sequence was the most complex to program of all of the cues in the show. Because of where the screen started for this movement, I had limited space to move the screen in an interesting way before it was out of sight. Adding too many movement points close together forced the motors to ramp up and down quickly, and made it difficult to get a delicate path to make the illustration of thought feel light and airy. Through several iterations of programming techniques, as discussed earlier under Cueing, Chapter 3, I was able to achieve an appropriate path. Furthermore, the timing of this scene needed to be precise in order to amplify the effect. The image flashes needed to be timed to appear as the characters were saying the words and the screen needed to be out of sight by the time the moment concluded. By listening to the music ahead of time, I was able to time the Watchout™ image sequences so they were close to what they needed to be, however in actual performance of the scene the timing was not quite right. Again, this is where a video of the scene in rehearsal became helpful for me since I could dial in the precise timing of the sequence to the actual performance and place where the projection and automation cues needed to happen.

The sequence is one projection cue and one automation cue. The projection cue begins on the static screen flashing the first round of food images. Then, as Alice joins the

Enchanted Table, an automation cue begins the screen's movement while the same projection cue continues to run. Watchout™ knows where the screen is initially because Spikemark™ retains position at all times, so the projection is able to begin on the static screen in its starting location. Then when the screen begins moving, the open stream of communication between Watchout™ and Spikemark™ allows the projection cue to continue as is while it follows the automated path of the screen.

Working on this sequence was important to the development of the Watchout™ and Spikemark™ integration because its complexity provided a real challenge to negotiating how all of the components could function smoothly. It demanded more refined motor tuning and cue programming in order to reduce the media's vibration while in motion. In addition, it generated techniques for achieving greater perceived accuracy of the image tracking. Furthermore, it pushed the visual composition of this scene into being a more vibrant experience.

THE HEAD OF THE CHESHIRE CAT

In Act 2, Scene 14, Alice is invited to play croquet with the Queen of Hearts. At one point during the games, visible only to Alice, a giant head of the Cheshire Cat appears. Motivation for the Cat's presence in this scene is found in the original illustrations for *Alice in Wonderland* seen in Figure 11. Similar to the "Alice Sees into the Garden" movement, the screen flies in with a giant still image of the Cheshire Cat's face, except this time it flies in at its stage left most position. His character's magical, all knowing presence looms over the scene until it comes to life with him saying "Look to the tarts!" in a booming voice. He is calling attention to the Knave of Hearts character who is about to steal the Queen's tray of cherry tarts. On the screen, we see the video of the Cheshire Cat saying his line as it fades into an image of a tray of cherry tarts.

For this scene, I faced a similar media problem as I did with trying to isolate Alice's eyes. I began by taking a close up video of the actor playing the Cheshire Cat in his costume and makeup against a black background grimacing into the camera and then delivering his line. However, I wanted to highlight Cheshire Cat's iconic smile, so I again used a feathered border on this video, though slightly less opaque and, this time, positioning it so that the character's smile was prominent and the rest of his face was in shadow. The screen flies in

with a paused video of the Cheshire Cat's grimacing face in the same motion path as it did for the "Alice Sees into the Garden" scene, the exception being that it came in at a different point on the X-axis. At the moment when the Cheshire Cat speaks his line, a Watchout™ cue plays the video in sync with the recorded sound of the character delivering his line. The same projection cue continues to a crossfade of the video into the tray of cherry tarts image.

Figure 11. Original *Alice in Wonderland* illustration of the Head of the Cheshire Cat from Tenniel, John. *Executioner Argues with King about Cutting off Cheshire Cat's Head*. 1865. *The Project Gutenberg*. Web. 29 Mar. 2015.

For this scene, the flexibility of the automated screen's placement was invaluable. I originally planned for the Cheshire Cat's head to be featured center stage. However, I

discovered in a technical rehearsal that this caused a problem because it blocked the sightlines to action happening on the higher levels of the scenery. The director suggested balancing the stage by moving the screen to its stage left most position, which, because of the integration, was an easy fix that we could make on the spot since once the screen was relocated, Watchout™ would still know where to deliver the media. In addition, making this move gave me a new idea for the screen's use: to enhance the whimsy of the Stolen Tart Dance.

Figure 12. Stage photo of the Head of the Cheshire Cat for *Alice: Curiouser and Curiouser.*

STOLEN TARTS DANCE

With the Cheshire Cat's warning, the crowd realizes that the Knave of Hearts is about to steal the Queen's tray of cherry tarts. At this point, a dramatic lighting shift and dance sequence occurs as the Knave runs around the stage with the tart tray. During the dance, the tracking screen makes a whimsical movement to the other side of the stage carrying the

image of the tart tray with it. The movement lasts for the duration of the dance and upon reaching the other side of the stage, the cherry tart tray image fades into the Queen of Heart's Coat of Arms to establish the next scene as the Court of the Queen of Hearts.

The conception of this sequence happened organically during the technical rehearsal process. Prior to the rehearsal, we knew we wanted to use the screen to portray the Cheshire Cat head and we knew we wanted it to aid in establishing location for the Queen's Court. After seeing the choreography, music, and lighting cues come together, it felt natural to include the automated projection screen. This sequence runs from an automation cue that takes the screen in an undulating path to the other side of the stage. Unlike in the "Drink Me" potion scene, I had more space to make larger movements, so I was able to make a smooth motion path without much tweaking. Figure 7, p.24 depicts the motion path for this scene. When the screen reaches its destination at the end of the dance, a Watchout™ cue runs the fade of the cherry tart tray into the Coat of Arms image.

Perhaps the most challenging media creation was for this sequence. The tray of cherry tarts could not be an arbitrary tray because we see the Knave carrying a tray of tarts so I needed to project an image that more or less matched the prop he carried. Unfortunately, while the prop looked good from a distance, it was not photo quality. I also could not find an appropriate image to use, so I composed one in Photoshop. Additionally, the Coat of Arms media proved challenging because my reference image was a small part of an original *Alice in Wonderland* illustration of the Court. I enlisted the help of the scenic designer to redraw this image for me so I could then manipulate it in Photoshop to make it look three dimensional like the rest of the media.

The Act 2 use of the automated projection screen was a successful example of using the full range of the screen's motion. The visual necessity of having the screen start on stage left and end on stage right for the next scene was made possible with the use of this integration. Without this range of capability, the design for these moments would have suffered. Discovering the Tart Dance movement was a bonus. Through this design, we were able to add playful excitement to the chase by having the image of the tarts moving across stage as the real tarts were moving too.

Figure 13. Production Photo of the Stolen Tarts Dance in *Alice: Curiouser and Curiouser*.

CHAPTER 5

REFLECTIONS

Carrying this project through the testing and production phases was an important beginning to researching this integration. It allowed me to discover all of the nuances involved and identify areas that need further development and understanding. Being both the technical designer as well as the artistic designer was invaluable to my process. I was able to push both sides of the equation and really discover the capabilities of this integration. My technical knowledge encouraged me to design more complex sequences, and my artistic experience forced me to develop techniques to refine the technology to achieve the desired effect. I am proud of this work as a first iteration for the San Diego State Theatre Department, though I recognize areas needing improvement. Through continued use of this integration, we can truly contribute to its improvement. The areas which I hope to continue researching are:

- **Pixel Scale Factor**
  Conducting experiments to determine a formula for accurately calculating the pixel scale factor needed for the tween formula would be incredibly helpful to the efficiency of this system's installation. Since we value quick setup in theatre, it is important to get this number as close as possible to minimize the amount of trial and error during programming.
- **Integration-Specific Machine Design**
  My machinery resources to conduct this research were limited to the equipment available in the stock of the SDSU Theatre Department. While this is quality equipment that was indeed capable of producing a successful result, I would improve upon this by incorporating a mechanical design, which takes into account factors specific to moving a projection screen. Refining the machine design would allow me to get closer to achieving the automated motion path that Watchout™ simulates.
- **Experimenting with controlling other tween tracks**
  A position tween is the natural choice for external control by the automation software. However, I would experiment with how these numbers might manipulate media in other ways beyond simply moving it with the screen in order

to push the designs forward. I believe these experiments could lead to some very dynamic effects.

With the information provided thus far in this thesis, I hope to encourage future generations of SDSU theatrical designers to continue to create in a fluid way. I hope that the new designs we conceive will further the development of the Watchout™ and Spikemark™ integration.

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APPENDIX

EXCERPT FROM THE SPIKEMARK™ 3.2 MANUAL

Projection design is commonplace in an increasing number of theatrical performances. With media servers and automation gear existing on the same network, it seems obvious that these systems should share data to create stunning effects by coordinating video and scenic motion. To that end, Spikemark™ now has the ability to output position data from any motor in a show to a WATCHOUT™ media server. It takes a little extra configuration in Spikemark™ and WATCHOUT™ to get both systems talking to each other, but the effort is reward with truly stunning effects. Alright, let's get started.

Assume that we have a little show with an automated wall panel attached to a traveler track. On cue, the wall panel will track from Stage Right to Stage Left. As the panel tracks across the stage, we need to project a graphic onto the panel and have the image move along as if it were glued to the panel. Here's a screen shot of the Spikemark™ cue (Figure 350):

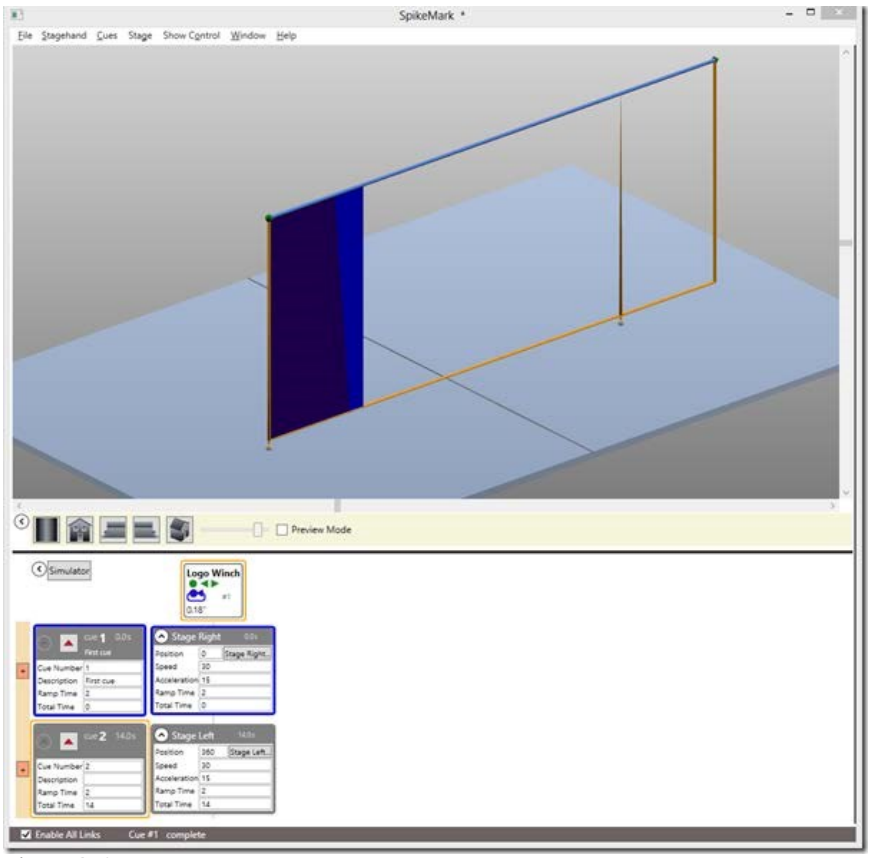

Figure 350

In order for WATCHOUT™ 's projectors to track an image synchronously with the motorized panel, we need to send the position of the panel to WATCHOUT™ . Spikemark™ will communicate with WATCHOUT™ over the Ethernet network, so both the Spikemark™ automation computer and the WATCHOUT™ production computer need to be plugged into the same physical network. In addition, the two computers need to have compatible IP Addresses that share the first three segments of the address with unique fourth segments. I have the addresses assigned as such: Spikemark™ computer is 192.168.10.119 (Figure 351)

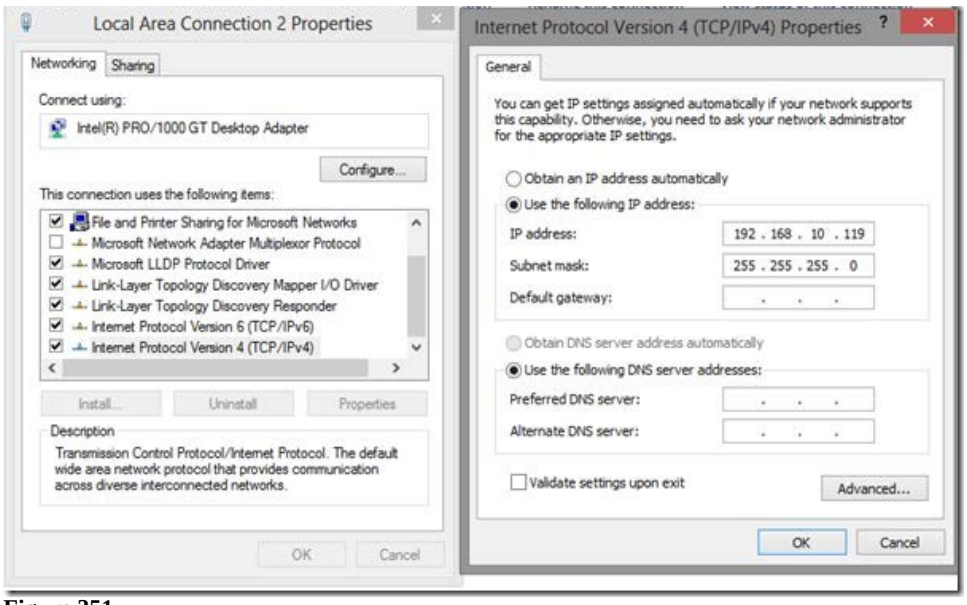
Local Area Connection 2 Properties
Networking
Sharing
Connect using:
Intel(R) PRO/1000 GT Desktop Adapter
Configure...
This connection uses the following items:
File and Printer Sharing for Microsoft Networks
Microsoft Network Adapter Multiplexor Protocol
Microsoft LLDP Protocol Driver
Link-Layer Topology Discovery Mapper I/O Driver
Link-Layer Topology Discovery Responder
Internet Protocol Version 6 (TCP/IPv6)
Internet Protocol Version 4 (TCP/IPv4)
Install...
Uninstall
Properties
Description
Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.
OK
Cancel
Internet Protocol Version 4 (TCP/IPv4) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address:
192 . 168 . 10 . 119
Subnet mask:
255 . 255 . 255 . 0
Default gateway:
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server:
Alternate DNS server:
Validate settings upon exit
Advanced...
OK
Cancel

Figure 351

And the WATCHOUT™ computer is 192.168.10.9 (Figure 352)

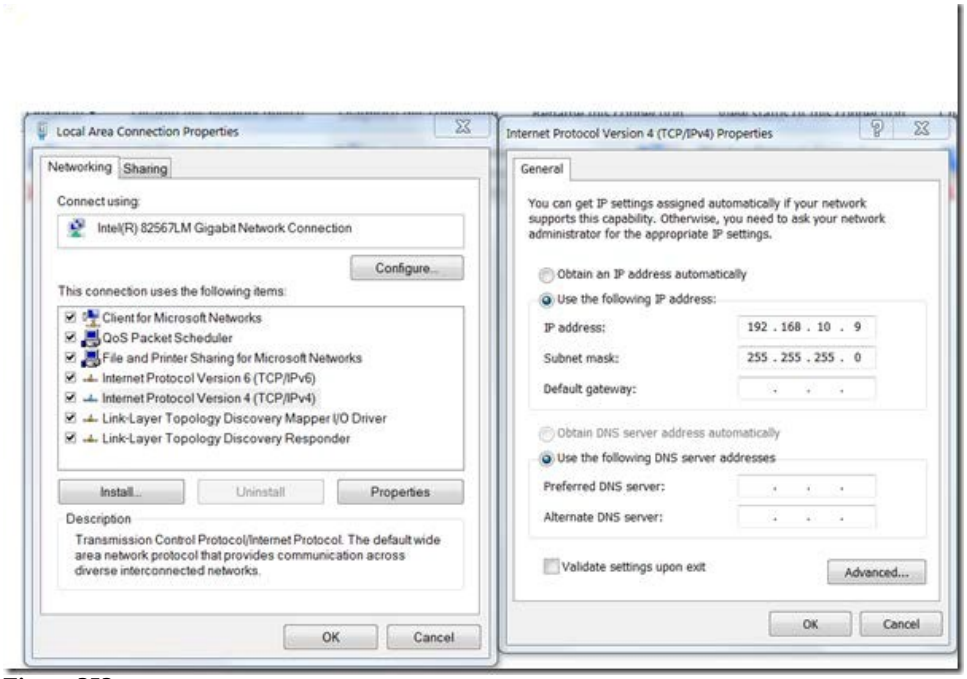
Local Area Connection Properties
Networking
Sharing
Connect using:
Intel(R) 82567LM Gigabit Network Connection
Configure...
This connection uses the following items:
Client for Microsoft Networks
QoS Packet Scheduler
File and Printer Sharing for Microsoft Networks
Internet Protocol Version 6 (TCP/IPv6)
Internet Protocol Version 4 (TCP/IPv4)
Link-Layer Topology Discovery Mapper I/O Driver
Link-Layer Topology Discovery Responder
Install...
Uninstall
Properties
Description
Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.
OK
Cancel
Internet Protocol Version 4 (TCP/IPv4) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address:
192 . 168 . 10 . 9
Subnet mask:
255 . 255 . 255 . 0
Default gateway:
Obtain DNS server address automatically
Use the following DNS server addresses
Preferred DNS server:
Alternate DNS server:
Validate settings upon exit
Advanced...
OK
Cancel

Figure 352

With both computers addressed properly, we need to tell Spikemark™ where to send the position data. In Spikemark™ select **Watchout™** from the **Show Control** menu (Figure 353).

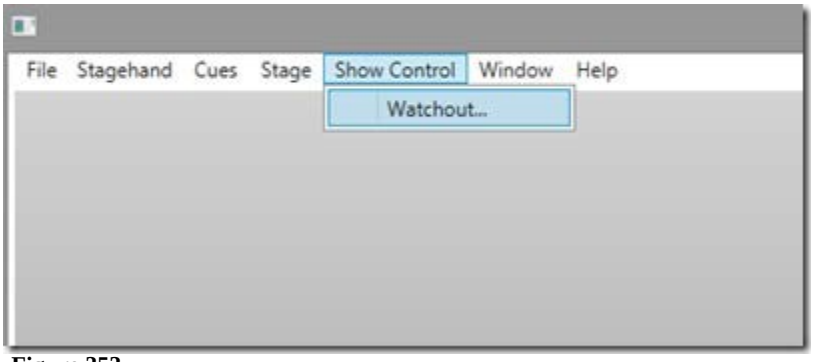

Figure 353

A dialog pops up with some configuration details that determine what data is sent to WATCHOUT™ (Figure 354).

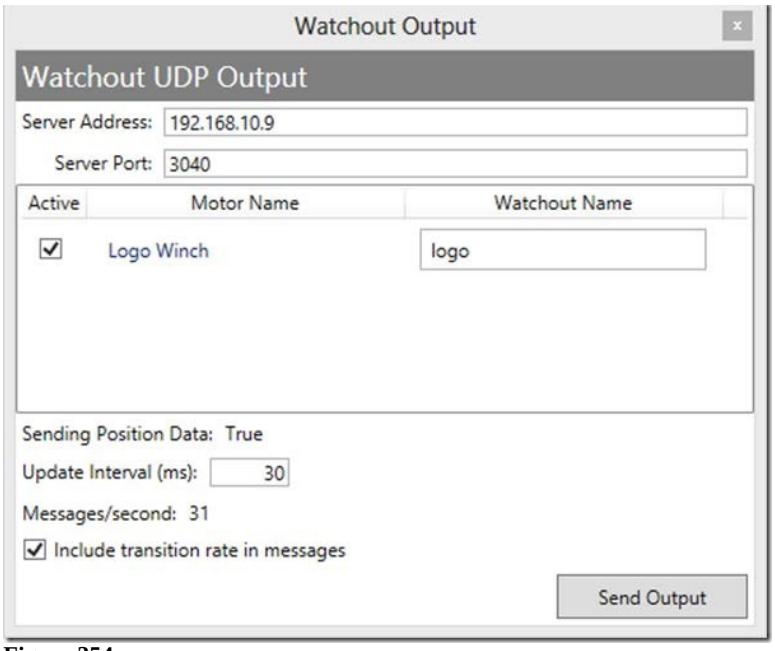

Figure 354

From the top the options are:

1. **Server Address**: The IP Address of the WATCHOUT™ production computer
2. **Server Port**: The port where WATCHOUT™ listens for incoming data. By default, WATCHOUT™ listens on 3040.

3. **Motor List**: Each motor in your show is listed. If the **Active** box is checked, that motor's position information will be sent to WATCHOUT™ . In the **Watchout™ Name** text box you can enter a name that will be used inside WATCHOUT™ to

identify the motor's position. The Spikemark™ motor name and the WATCHOUT™ name can map however you like. For example, we could have called it "Logo Winch" in Spikemark™ and "fuzzy pink rabbit" in Watchout™ .

4. **Sending Position Data**: Indicates whether Spikemark™ is currently sending UDP packets to the address indicated in **Server Address**.

5. **Update Interval (ms)**: The frequency with which Spikemark™ will send position updates to WATCHOUT™ . The number entered here will determine how many milliseconds should elapse between updates, so higher numbers will result in a slower update cycle. In practice, 30ms is about the fastest rate consistently possible without adversely affecting Spikemark™ 's performance.

6. **Messages/second**: The number of position updates that are actually being sent to WATCHOUT™ each second. This number will often bounce around by 1 or 2 messages.

7. **Include transition rate in messages**: If checked, Spikemark™ will send WATCHOUT™ the number of milliseconds that have elapsed since the last position update.
   WATCHOUT™ can use this information to smooth the animation of the image as it tracks with the motor. This generally results in a smoother visual result, but can be slightly inaccurate. Feel free to experiment with either setting to get the most appropriate result for your show.

8. **Send Output**: This is a toggle button to turn on/off the data stream from Spikemark™ . The data is sent via UDP, which is a connectionless protocol, so there is no harm sending out the packets even if WATCHOUT™ is disconnected from the network. UDP packets will blissfully fall into oblivion if the server is not around to receive them so you can start the output stream before WATCHOUT™ is running.

With Spikemark™ configured and the **Send Output** button depressed, we are ready to fire up the WATCHOUT™ production machine. Start WATCHOUT™ and give your show file a name. As I mentioned when we started, I need an image to be projected on the traveler panel, so our first step in WATCHOUT™ is to import an image (Figure 355).

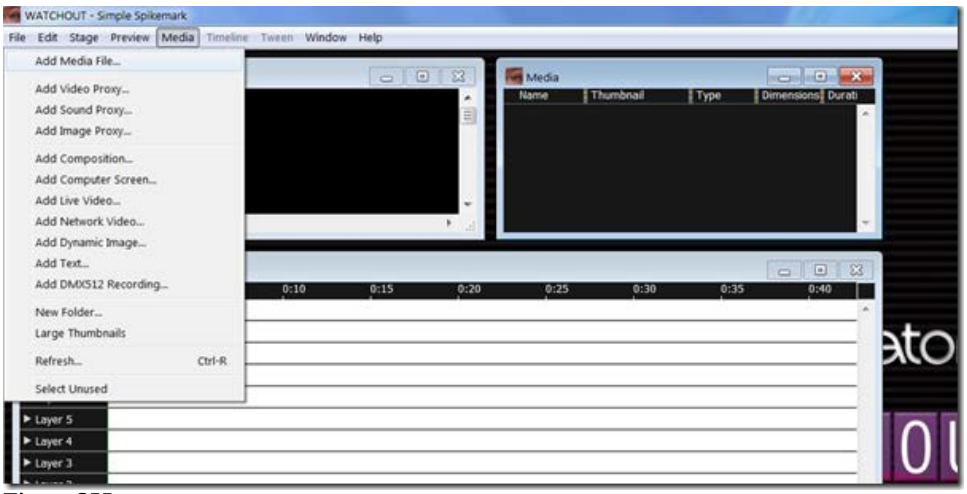

Figure 355

I selected a Creative Conners Logo image, which shows up in the **Media** list (Figure 356).

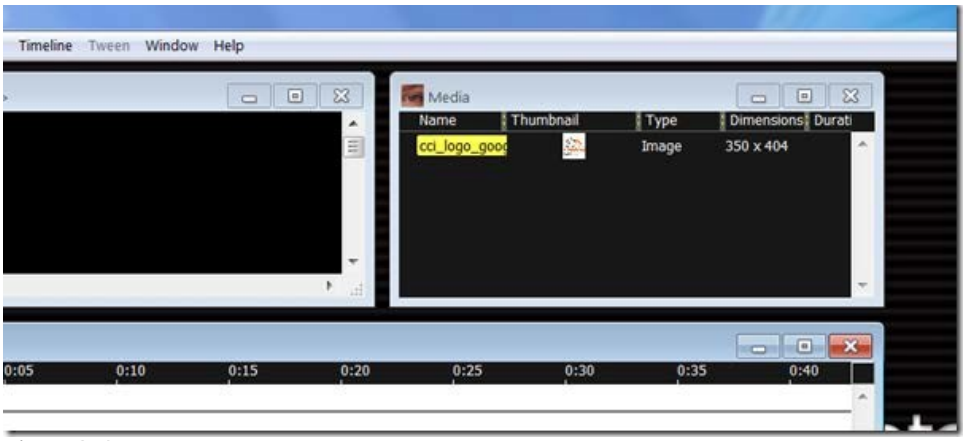

Figure 356

Now drag the image from the **Media** list into the **Stage** window. You can see the image displayed in the center of the **Stage** view and it also shows up in the **Main Timeline** (Figure 357).

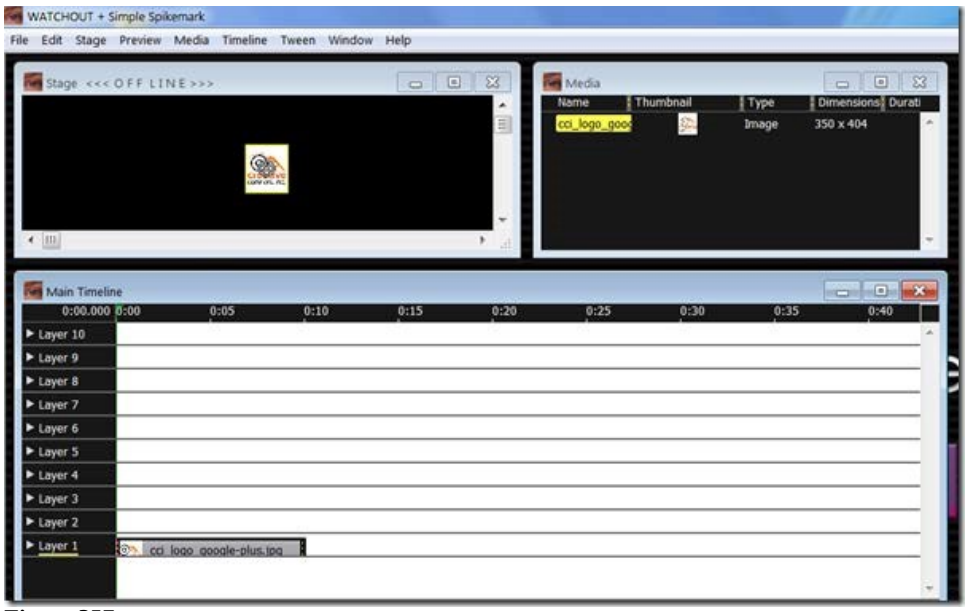

Figure 357

With the image on our virtual stage, we need start configuring WATCHOUT™ to listen for data from Spikemark™ . We have to enable an external source (Spikemark™ in this case) to control the image position. Double-click on the image in the **Media List** and select **More Effects and Capabilities** (Figure 358).

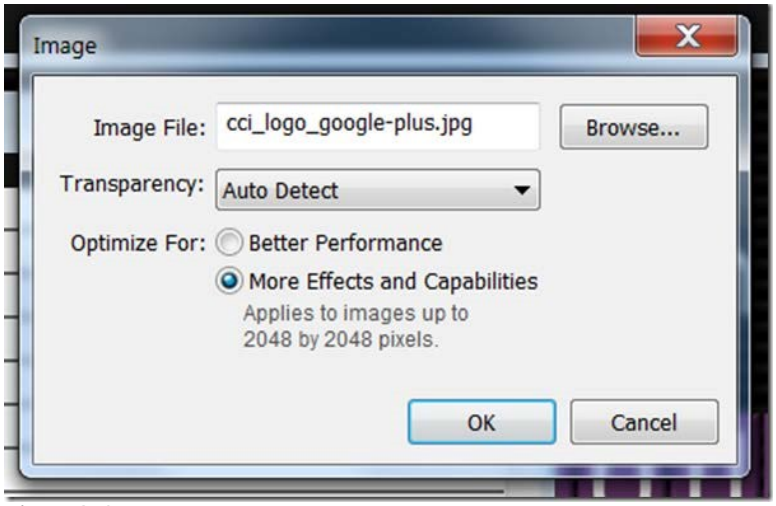

Figure 358

Then, in the **Main Timeline**, double-click on the image layer to bring up the **Media Cue** properties window. Select the **Advanced** tab and check **External Control of Position, Scale & Rotation** (Figure 359)**.**

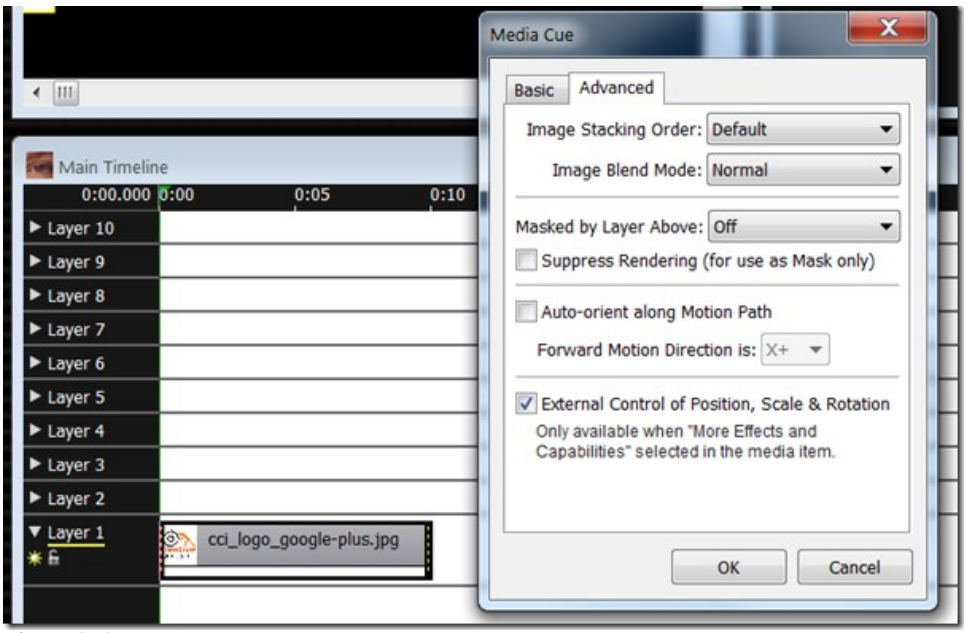

Figure 359

Our next step is to create a **Generic Input** in WATCHOUT™ that has a name that matches the

Watchout™ Name we entered into Spikemark™ . We will use the data received from that **Generic Input** to move the image around. To add a **Generic Input** select **Input** from the **Window** menu (Figure 360).

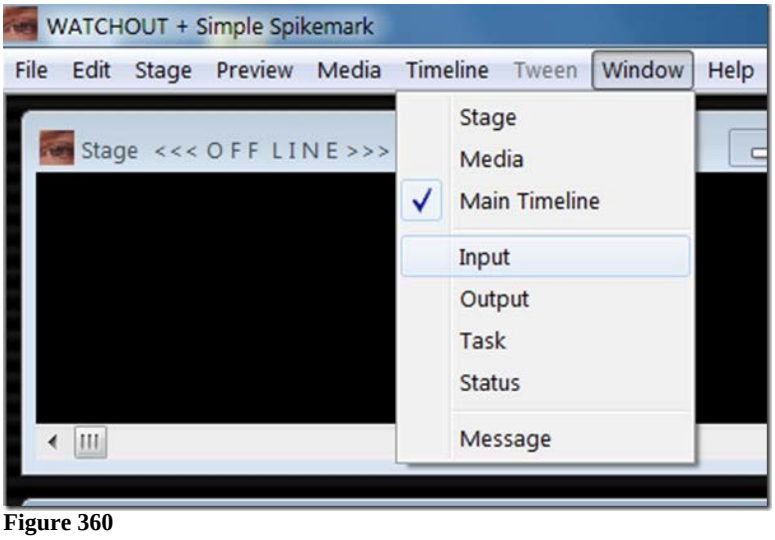

Figure 360

From the **Input** window, click on the little triangle in the upper right corner. From the menu that appears, select **Add Generic Input** (Figure 361).

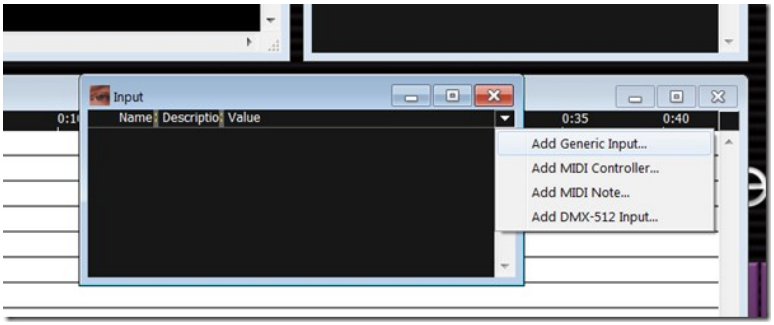

Figure 361

A dialog is presented where you can enter the **Name** of the input and the **Limit** of the input value. This step is important to get correct. The **Name** needs to match the name entered in the Spikemark™ **Watchout™ Output** window… exactly, same case, same spelling, etc. The **Limit** should match the highest value expected to come from Spikemark™ . In this case, our traveler has a maximum forward position of 360", so we can enter 360 (Figure 362).

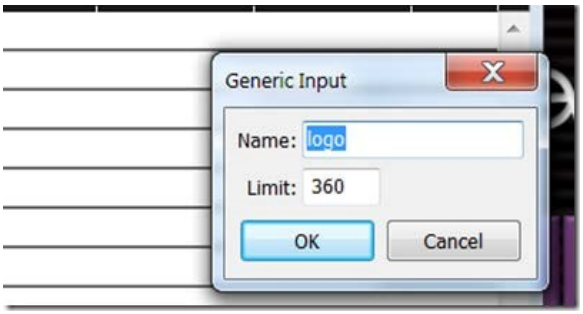

Figure 362

Press the OK button and then the new Generic Input will be listed in the Input list with its current value set to 0.00 (Figure 363).

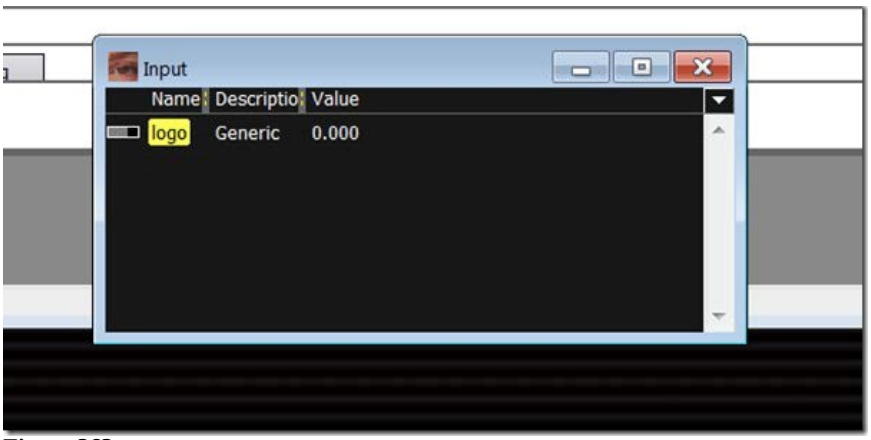

Figure 363

Now, the next step is to connect the value of the **Generic Input** to the x-axis of the Image so that the Image will move as the **Generic Input** value changes. To link the image position to the **Generic Input** value we will create a formula in the **Main Timeline**. Select the image layer in the **Main Timeline**, and then from the **Tween** menu select **Position** (Figure 364).

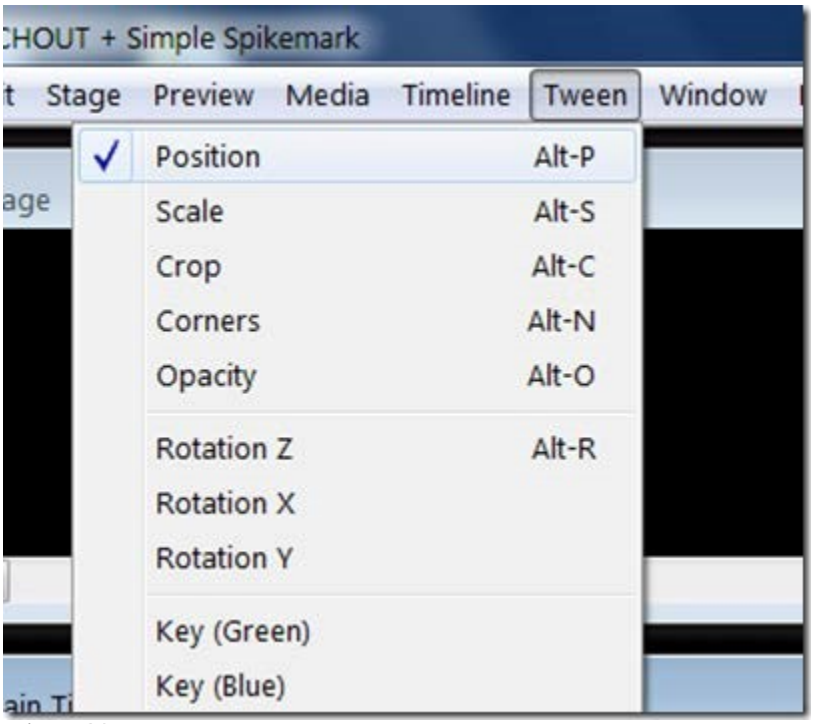

Figure 364

This adds a **Position** tween track below Layer 1 in the **Main Timeline**. This is the good part. Now that we have a tween for Position, on the left side of the track there is a little round

button with an “f” inside. That allows us to write a formula that will link the position of the image to the value of the **Generic Input**, the value of the **Generic Input** will be connected to the data stream from Spikemark™ , and the data stream from Spikemark™ is driven by the position of the scenery. The knee bone is connected to the leg bone… still with me? Great, click the little *f*unction button (Figure 365).

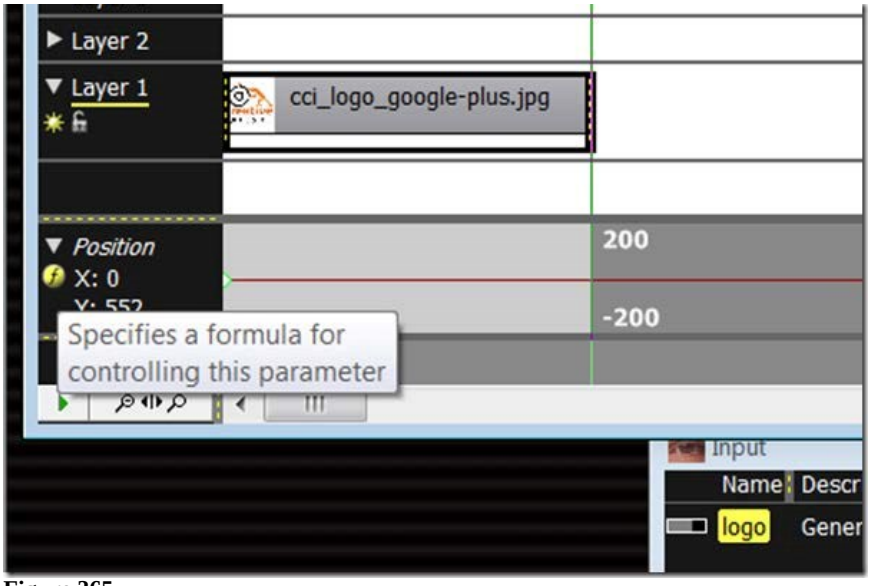

Figure 365

In the dialog box that appears, we enter in a formula in the X axis text box. Since this is a traveler track, we want to manipulate the lateral position of the image, but if it was a flying piece of scenery we could instead control the Y axis of the image. To use the value of the **Generic Input**, we simply type the name of the input. In this case, I’m multiplying the value of the input by 10 to get the image to track the correct number of pixels across the stage. The multiplier you use can be adjusted to fit the specific show (Figure 366).

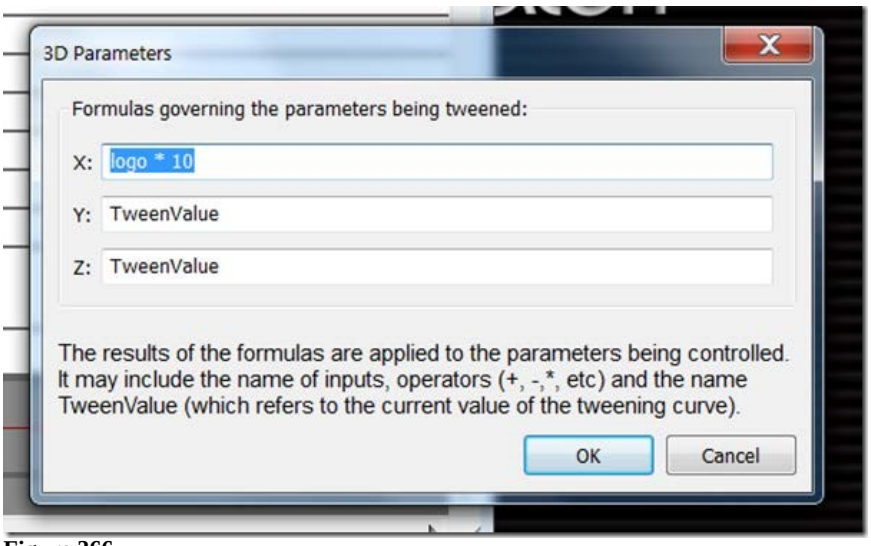
3D Parameters
Formulas governing the parameters being tweened:
X: logo * 10
Y: TweenValue
Z: TweenValue
The results of the formulas are applied to the parameters being controlled.
It may include the name of inputs, operators (+, -,*, etc) and the name
TweenValue (which refers to the current value of the tweening curve).
OK
Cancel

Figure 366

We are almost there. Before flipping the last switch to connect Spikemark™ to WATCHOUT™ , try clicking around in the **Value** column of the **Input** list. This will manually adjust the value of the **Generic Input** and if everything is correct so far, as you alter the **Generic Input Value** the image should jump to a new X position in the **Stage** window (Figure 367).

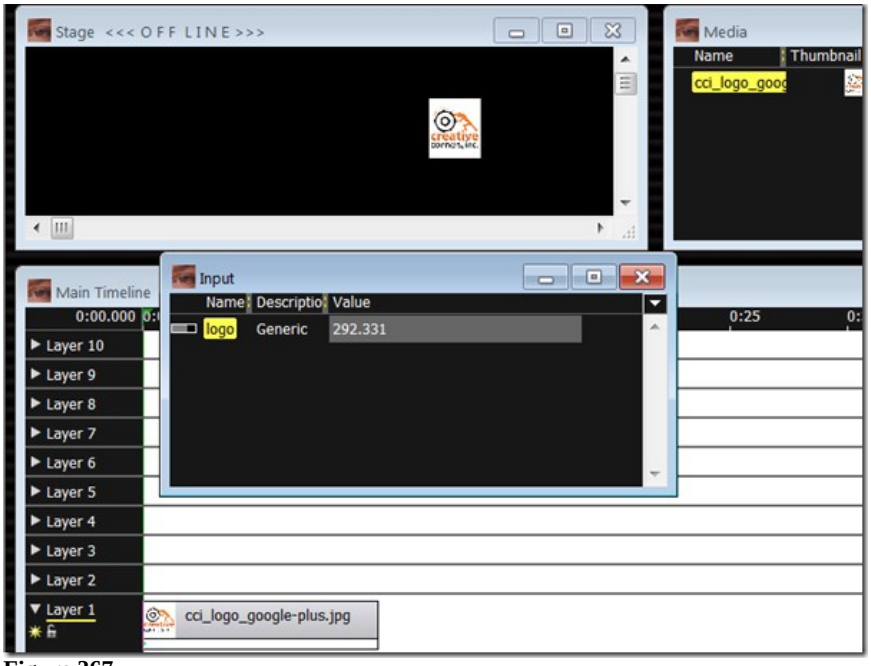

Figure 367

Alright, let's get the WATCHOUT™ computer listening to the Spikemark™ computer. From the **File** menu select **Preferences**. Then from the **Control** tab, check the **UDP** box next to **Production Computer Control** (Figure 368).

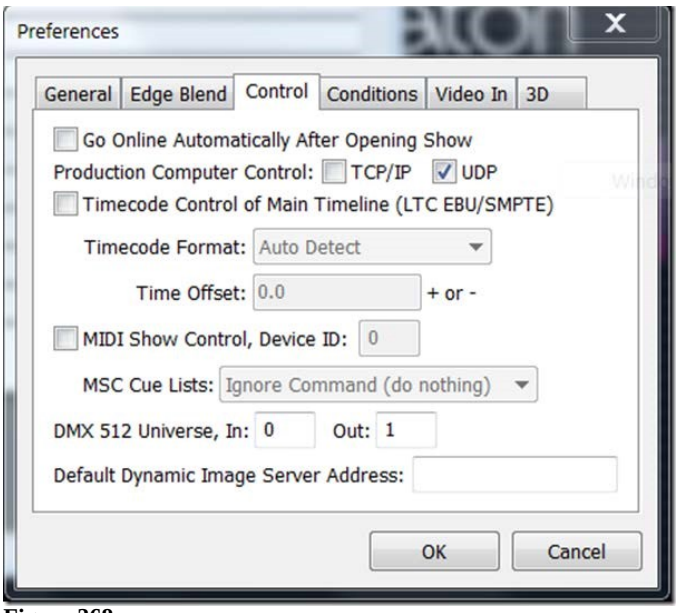

Figure 368

As soon as you click **OK**, WATCHOUT™ will start picking up the position data stream from Spikemark™ (assuming you depressed the **Send Output** button in Spikemark™) and the image will snap back to match its X position with the motor position. Also, the **Generic Input Value** should track with the motor position.

Let's load up cue #2 in Spikemark™ . Notice that the current motor position is 0.18" in Spikemark™ , and that the Generic Input Value in WATCHOUT™ is 0.175 showing that the two systems are communicating (Figure 369, Figure 370).

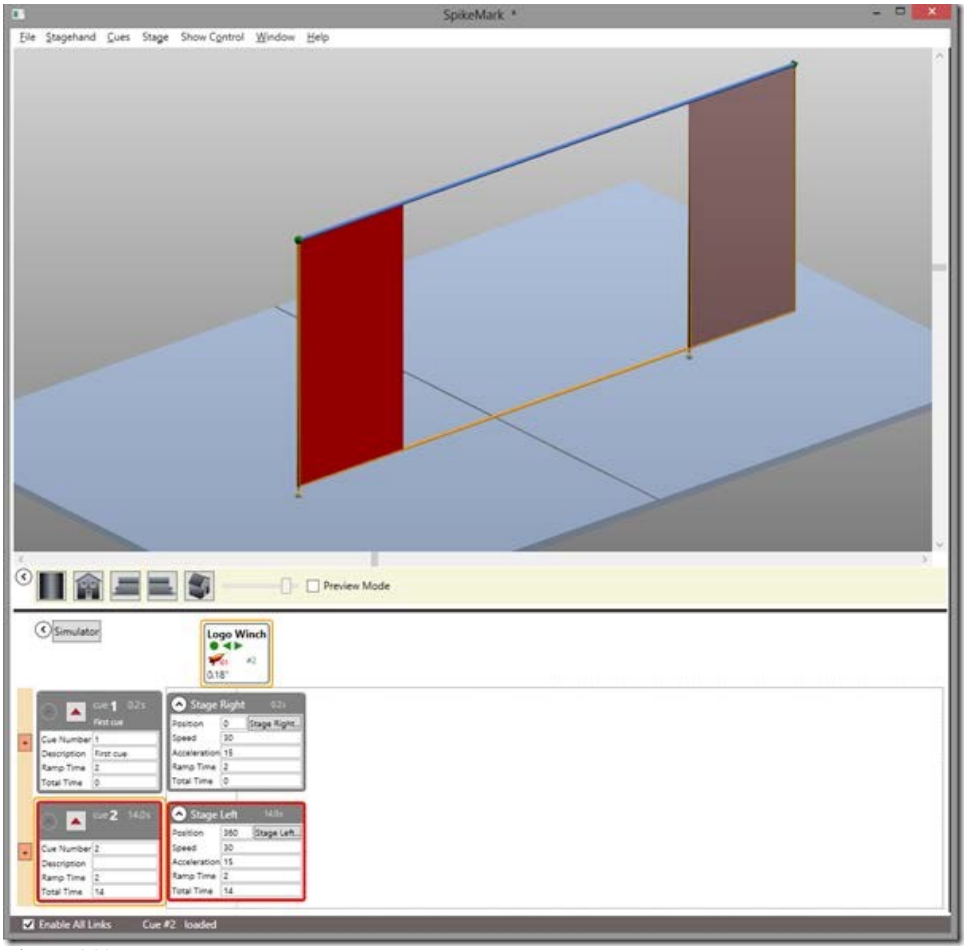

Figure 369

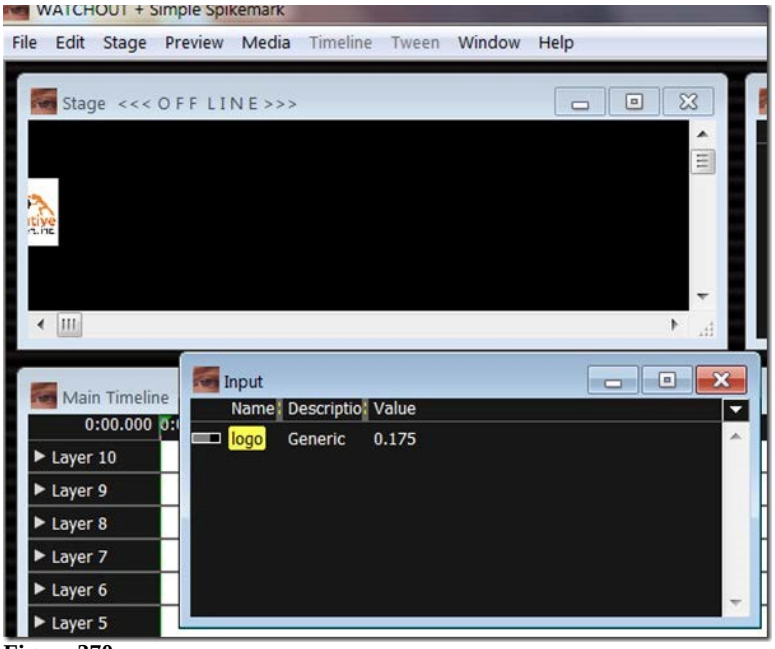

Figure 370

Now, let's run cue #2 in Spikemark™ (Figure 371). When it completes, we can see that the image tracked across the stage in WATCHOUT™ , matching the motor position! (Figure 372)

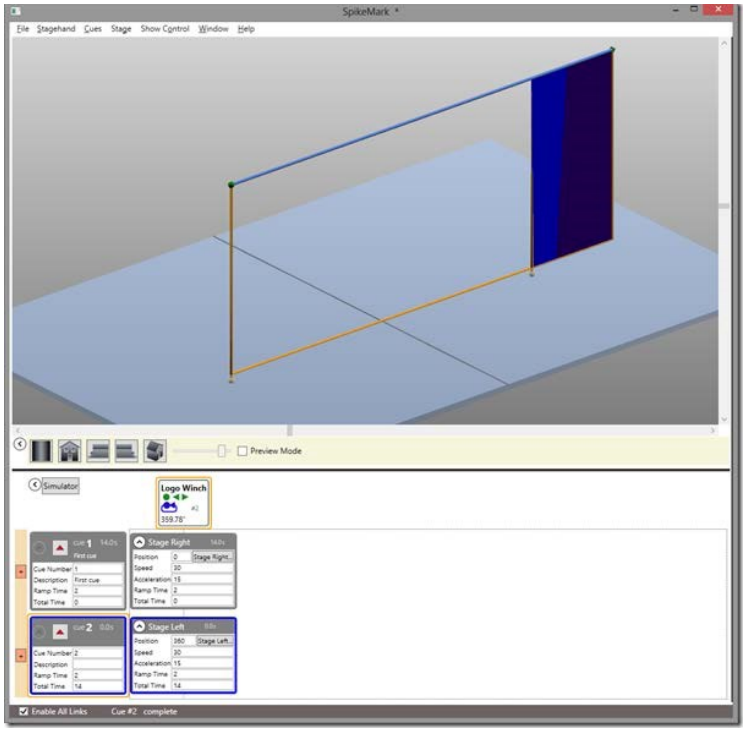

Figure 371

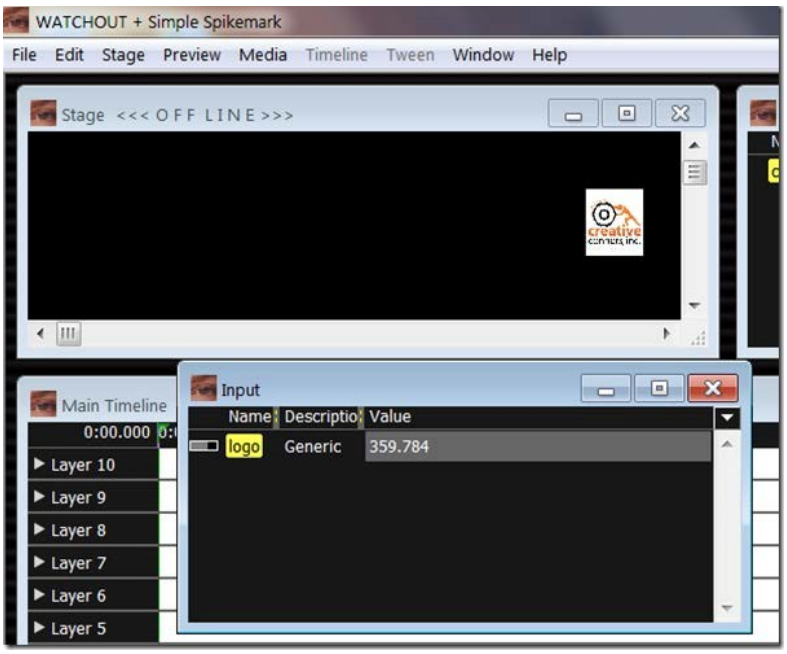

Figure 372

I hope this gives you a little inspiration to create some stunning stage effects. This tutorial is just a taste of what can be achieved when Spikemark™ and WATCHOUT™ are used together in live theatre. As you start using this feature in production, please let us know how it works for you and send us some video. We love to see this stuff in action.